Undergraduate Major Programs

The university offers the following undergraduate major programs. While most of these programs are offered as majors within a specific academic department, in some cases subjects transcend departmental lines or are emphases within a major program. Minors are available. Programs that are offered only as minors are described under the entries for individual colleges in Section III, Academic Programs in the Colleges, and under individual departments in Section V, Description of Courses. Graduate programs are offered in many of the subjects listed. These are described in Section IV, Graduate Study and Research.

<table>
<thead>
<tr>
<th>Accounting</th>
<th>Electrical Engineering</th>
<th>Mechanical Engineering</th>
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<tbody>
<tr>
<td>American Studies</td>
<td>/Engineering Physics*</td>
<td>Molecular Biology</td>
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<tr>
<td>Anthropology</td>
<td>Engineering Mechanics</td>
<td>Music</td>
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<tr>
<td>Architecture</td>
<td>Engineering Physics</td>
<td>Natural Science</td>
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<td>Art</td>
<td>English</td>
<td>Philosophy</td>
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<td>Asian Studies</td>
<td>Environmental Sciences</td>
<td>Physics</td>
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<td>Behavioral Neuroscience</td>
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<td>Political Science</td>
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<td>Biochemistry</td>
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<td>Biology</td>
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<td>Chemical Engineering</td>
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<td>Chemistry</td>
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<tr>
<td>Civil Engineering</td>
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<td>Civil Engineering</td>
<td>Interdisciplinary Studies</td>
<td>Russian Studies</td>
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<tr>
<td>/Environmental Sciences*</td>
<td>International Careers</td>
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<td>Classical Civilization</td>
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<tr>
<td>Classics</td>
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<tr>
<td>Cognitive Science</td>
<td>Journalism/Science Writing</td>
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<td>Computer Engineering</td>
<td>Management</td>
<td>Statistics</td>
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<tr>
<td>Computer Science</td>
<td>Marketing</td>
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<tr>
<td>Economics</td>
<td>Materials Science and Engineering</td>
<td>Urban Studies</td>
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<tr>
<td>Electrical Engineering</td>
<td>Mathematics</td>
<td>*5 year dual degree program.</td>
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Academic Departments

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<th>College of Arts and Sciences</th>
<th>College of Business and Economics</th>
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<td>Art and Architecture</td>
<td>Accounting</td>
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<td>Biological Sciences</td>
<td>Business</td>
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<td>Chemistry</td>
<td>Economics</td>
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<td>Earth and Environmental Sciences</td>
<td>Finance and Law</td>
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<tr>
<td>English</td>
<td>Management and Marketing</td>
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<td>History</td>
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<td>International Relations</td>
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<td>Journalism and Communication</td>
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<td>Mathematics</td>
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<td>Modern Languages and Literature</td>
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<td>Music</td>
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<td>Philosophy</td>
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<td>Political Science</td>
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<td>Psychology</td>
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<td>Religion Studies</td>
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<td>Sociology/Anthropology</td>
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<td>Theatre</td>
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<td>College of Education and Human Services</td>
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<td>Education and Human Services</td>
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<td>College of Engineering and Applied Science</td>
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<td>Chemical Engineering</td>
<td>Civil and Environmental Engineering</td>
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<td>Civil and Environmental Engineering</td>
<td>Electrical Engineering</td>
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<td>Electrical Engineering</td>
<td>Industrial and Manufacturing</td>
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<td>Systems Engineering</td>
<td>Materials Science and Engineering</td>
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<tr>
<td>Mechanical Engineering</td>
<td>and Mechanics</td>
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Lehigh University reserves the right at any time to change the rules and regulations governing admission, tuition, fees, regulations affecting its students.
LEHIGH UNIVERSITY MISSION STATEMENT

To advance learning through the integration of teaching, research, and service to others.

Excellence is the hallmark of a university of distinction. Excellence requires a total quality commitment, which must characterize every activity of Lehigh University. Lehigh is an independent, coeducational university with programs in the arts and humanities, business, education, engineering, and the natural and social sciences, offering bachelor’s degrees primarily to full-time, residential students and graduate degrees through the doctorate for both full-time and part-time students. Lehigh is small enough to be personal, yet large enough to provide stimulating diversity and to play important national and international roles.

Since Lehigh’s founding in 1865, the faculty has emphasized the integration of the academic disciplines, combining the cultural with the professionals, the theoretical with the practical, and the humanistic with the technological in a modern, liberal education that serves as preparation for a useful life. Lehigh is an intellectually unified community of learners, and in this sense Lehigh is an integral university.

Lehigh strives to earn international prominence as a university of special distinction through its integration of teaching, research, and service to society. The integrating element of teaching, research and service is learning, which is the principal mission of all members of the Lehigh community. Our mission of advancing learning has three aspects:

Teaching. The development of future leaders in our global society is first among Lehigh’s purposes and first among our achievements. Preparation for leadership requires the best of teaching, in which both mentor and student are so deeply engaged that they become joint owners of the learning process.

Research. Lehigh is deeply committed to the creative search for new understanding of nature and human society as an essential element of the learning process. The scholarly inquiry and research of Lehigh faculty and students add value to instruction on our campus, and contribute to the distinction of our university.

Service. The special commitment of the Lehigh community to experiential learning through service to others imbues the entire university with a sense of purpose and value in the larger society. Lehigh is extensively involved in developing partnerships with industry, government and others in education and human services to meet the needs of our society. In a societal sense, Lehigh is devoted to the concepts of unity, community, and cooperative achievement.

Lehigh believes that its graduates must develop critical thinking and effective communication as their habit; they must have both a broad understanding of human affairs and a domain of true competence; they are expected to live by a set of mature cultural and personal values, accept the virtue of work as a vehicle of service, and have the will to live and work with exceptional self-discipline.

Respect for human dignity is very important at Lehigh, a caring community deeply committed to harmonious cultural diversity as an essential element of the learning environment. In order that all members of the Lehigh community might develop as effective and enlightened citizens, the University encourages physical, social, ethical, and spiritual development as well as rigorous intellectual development.
I.

Information of General Interest

This section includes information related to accreditation, admission, advanced placement, transfer students, tuition and fees, financial aid, campus life and academic regulations. Similar information for graduate students may be found in Section IV. The university's history, biographies of its presidents and descriptions of its buildings are found in Section VI.

Accreditation

Lehigh University is accredited by the Middle States Association of Colleges and Schools.

Both the undergraduate general and accounting programs and the master of business administration programs are accredited by the American Assembly of Collegiate Schools of Business. The engineering curricula are accredited by the Accreditation Board for Engineering and Technology. In addition, the computer science program offered in the College of Engineering and Applied Science is accredited by the Computer Science Accreditation Board, Inc. The Commonwealth of Pennsylvania approves for educational certification various programs within the College of Education. Programs in chemistry are approved by the American Chemical Society.

The department of theatre is accredited by the National Association of Schools of Theatre, recognized by the U.S. Department of Education as the accrediting body for the field of theatre.

Policy of Equality

Lehigh University provides equal opportunity on the basis of merit without discrimination because of race, color, religious creed, ancestry, national origin, age, handicap, sex, sexual orientation or union membership.

Admission Guidelines

The total undergraduate and graduate enrollment of Lehigh University is regulated by action of the board of trustees, with a resulting limitation in the number of candidates who can be admitted each year to the various divisions of the university.

Because of the limitations on enrollment, the Office of Admissions, under the leadership of the Dean of Admissions and Financial Aid, conducts a selective review of candidates for admission. Several criteria are used in an attempt to predict a student’s ability to successfully complete four years of rigorous study at Lehigh University.

The material that follows pertains to undergraduates. Graduate students should consult Admission to Graduate Standing, Section IV.

The admission policy of the university is designed to enroll students with a variety of backgrounds. The course work or units required for admission represent the equivalent of the usual four-year college preparatory curriculum with certain specific course work being required for enrollment in certain programs within the university. Evidence of academic growth, ability to learn, and motivation are special qualities that may not be reflected in the accumulation of units. Such qualities are also considered by the admissions committee.

Minimum subject matter requirements (16 units)

- English 4 units
- foreign languages* 2 units
- social science 2 units

- laboratory science 2 units
- college preparatory mathematics 3 units
- elective subjects 3 units

*Only in exceptional cases, and for otherwise well-qualified candidates, will the Committee on Admissions waive the foreign language requirement for admission to any one of the three undergraduate colleges.

Students planning on enrolling in the College of Engineering and Applied Science must have studied mathematics through trigonometry, and should have studied chemistry, physics and mathematics through pre-calculus. Calculus is recommended. Students planning to enroll in the College of Business and Economics must have completed mathematics through trigonometry, but also should strongly consider taking pre-calculus or calculus. Candidates for the College of Arts and Sciences preparing for a bachelor’s of science degree must also take math through trigonometry.

Minimum course work requirements can be misleading since most students who gain admission to Lehigh University exceed the minimum course work. Strength of preparation can be difficult to assess since each individual comes from a different background. However, the Committee on Admissions will look for things such as (in no particular order):

- Rank or relative rank in class
- How the student’s grades compare to those of his or her classmates at that particular school
- Evidence of improvement or deterioration in grades during the secondary school career with particular attention paid to performance in senior year courses
- The quality of performance in courses that relate to the student’s anticipated area of study
- The difficulty of courses taken with special attention paid to courses recognized as being accelerated by national academic organizations
- Comments and recommendations from the principal, headmaster, guidance counselor, or other professional educators within the school system
- Performance on standardized testing
- Extra-curriculum/work experience with particular emphasis placed on demonstrated leadership
- Demonstrated interest in Lehigh University

Entrance Examinations

SAT/ACT: Each candidate for admission to the freshman class is required to write either the Scholastic Assessment Test (SAT) or the American College Test (ACT). It is highly recommended that the student request that his or her scores be forwarded to Lehigh (CEEB code 2365) directly. It is not the responsibility of the high school guidance office to forward the results. If, during the evaluation process, it is discovered that the test results are missing, the student will be notified by mail or phone. Unnecessary delays in the decision-making process can result if the committee does not have the scores.

The Committee on Admissions recommends that students take the exam in the junior year and again as early in the senior year as possible. In the evaluation process, the highest score in each category will be used regardless of the test date.

SAT II Tests: Candidates are not generally required to write any College Board SAT II tests. Students may submit them if they feel they will be helpful to the admissions process. The Office of Admissions also
reserves the right to request SAT II tests if the Committee on Admissions believes it will be helpful to evaluate a candidate's potential.

Test information and applications may be secured from high school guidance offices or the College Board at either of the following addresses: P.O. Box 592, Princeton, N.J. 08541, or 1947 Center St., Berkeley, Calif. 94704. Candidates writing tests outside the United States should direct their correspondence to the Princeton address.

Candidates should register for the tests early in the senior year and not later than one month prior to the test date (two months for candidates who will be tested in Europe, Asia, Africa, Central and South America and Australia).

As with other standardized testing, the candidate has the responsibility to have the results sent to Lehigh.

Recommendations
The Office of Admissions requires, as part of a candidate's file, a letter of recommendation from the guidance counselor, principal, or headmaster from the candidate's school. One teacher recommendation is also required. Such recommendations should address the candidate's other qualifications such as health, emotional stability, intellectual motivation, social adjustment, participation in school activities, and established habits of industry and dependability.

Interviews
Prospective freshmen and their parents are highly encouraged to visit Lehigh and to participate in a campus tour and to meet with an admissions officer for a personal interview or a general information session. No appointment is necessary for a campus tour or an information session, but interviews must be scheduled by appointment. A call to the Office of Admissions is recommended because the schedule of tours and interviews can change several times during the year as the academic calendar changes. While visiting our campus, it is often possible to meet with faculty, coaches or other professional staff of the university. Requests for such meetings should be made prior to the actual visit so as to facilitate scheduling.

The Office of Admissions is open for interviews most weekdays from 9 am to 11:15 am and from 1:15 p.m. to 3:30 p.m. Tours are available several times a day during the school year. Some Saturday morning tours and interviews are available during the fall and winter, but these time slots fill very quickly and students are encouraged to reserve a spot as soon as possible. No interviews are granted during the February 1 to April 1 period, when the staff is reading files; exceptions can be made for persons traveling great distances.

In certain cases, an interview may be required if, in the opinion of the Dean of Admissions and Financial Aid, the additional information gained through an interview would be helpful in making the correct decision regarding admission. In such cases, the candidate will be notified of our request.

How to Apply
Students may secure applications by writing to the Office of Admissions, 27 Memorial Drive West, Lehigh University, Bethlehem, PA 18015, or by telephoning (610) 758-3461. Students may also use the Common Application available from school guidance counselors, or they may apply by using the Common Application on-line. The Common Application is accepted as the equal of the Lehigh application.

Applications should be filed according to the following deadlines:
November 15 —Early Decision
December 1 —6 year BA/MD Program
January 1 —Penn-Dental 7 year Dental Program
January 1 —Regular Decision

Each application must be accompanied by an application fee of $50. This fee is non-refundable and does not apply towards the fall-term bill. Students who do not attend will forfeit their deposit.

Early Decision
Our program is a binding early decision plan, which means that the student, parents and guidance counselor must sign an Early Decision Request form to confirm their understanding that, if the student is accepted, the student is expected to accept our offer and withdraw all other applications. Students applying early should be sure that Lehigh is their first choice school. Students who meet the November 15 deadline will be notified by December 15. It is understood that the student will continue at a satisfactory level of academic performance throughout his or her senior year.

The early decision plan is not for everyone. It is for the student who has been early and active in their college search, and is sure that he or she wants to attend Lehigh. When reviewing an early-decision application, the committee will defer a decision on any candidate when there is insufficient information to make an early decision. It is also possible that a student may be denied admission. The Committee will give early-decision applicants some slight advantage in borderline cases because of the commitment of applying early, but students must still present a strong record.

Early decision candidates who have filed the Financial Aid Profile application and prior year tax forms will be notified of their financial aid packages approximately three weeks after the decisions on admission are made by the Office of Admissions. All other financial aid forms must be filed by the deadline indicated on each application.

Admission and Deposit
Notification of admissions decisions are made by mail by the first week of April. Admission is granted only through written notice by the Office of Admissions. An admitted student may secure a place in the entering class by notifying the university that he or she intends to enroll at Lehigh and by forwarding the appropriate enrollment deposit by May 1. This fee is applicable towards the fall-term bill. Students who do not attend will forfeit their deposit.

Transfer Students
Each January and August, students who have attended another college or university are admitted with advanced standing. Candidates for transfer admission must meet the high school subject matter requirements prescribed for entering freshmen, but entrance examinations are not required. The academic performance at the college level is the primary focus when giving consideration to admission.

Candidates who have been dropped for poor scholarship, or who are not in good standing, or who have been released for disciplinary reasons are not eligible for admission.

Each candidate must submit an official transcript and course descriptions from each institution attended. An admissions decision cannot be made without this information. Students wishing to enter in the spring should apply no later than November 1 and applicants for the fall semester should have their application in by April 1. Applications may be obtained by writing to the Transfer Section, Office of Admissions, 27 Memorial Dr. West, Lehigh University, Bethlehem, PA 18015 or by calling (610) 758-4681. The application is also available at Lehigh's web site at www.lehigh.edu/admissions/transfer.html. Each application must be accompanied by an application fee of $50.

Students are encouraged to take an active role in seeing that the various parts of the student's admission packet have arrived at the university. Decisions are made as soon as possible after the application is complete. Students will be notified by the Registrar as to how many credits Lehigh will grant to the student in advanced standing.
Housing: Transfer students are guaranteed housing for at least their first semester. All students are guaranteed on-campus housing through the end of the sophomore year. Contact the Office of Residential Services, Rathbone Hall, Lehigh University, 63 University Drive, Bethlehem, PA 18015 or call (610) 758-3500. This office also can provide information about off-campus housing. Fraternities and sororities often have room for members or boarders. Information on this option may be obtained through the Dean of Students, Coordinator of Greek Affairs, University Center, 27 Trembley Drive, Lehigh University, Bethlehem, PA 18015 or call (610) 758-4157.

Advanced Placement
The university offers eligible students who have superior preparation an opportunity for advanced placement and/or college credit. Many secondary schools, in association with the College Board, offer college-level work. Students participating in these courses should write the Advanced Placement Tests offered by the College Board.

Students who achieve advanced placement are afforded three major advantages. First, they commence study at Lehigh at a level where they will be academically comfortable. Second, students who qualify for college credits may be graduated at an earlier time— with resulting savings in time and tuition outlay. Third, qualified students may, in the Lehigh senior year, enroll for a limited amount of work for graduate credit.

Entering freshmen that ask the College Board to send their advanced placement grades to Lehigh are considered for advanced placement.

Some departments noted below offer examinations during Freshman Orientation to students who studied college-level subjects in secondary school but did not write the advanced placement tests. Entering freshmen wishing to write an examination in any Lehigh course should notify the Office of Admissions in writing prior to August 1. The student should specify the number and title of the course. Students who receive credit on the basis of advanced placement grades need not write Lehigh tests to confirm the credit granted.

Current practice at Lehigh is as follows:

**Art and Architecture.** Six credit hours for Art 1 and Art 2 are granted to students who earn a grade of 5. Three credit hours for Art 1 are granted to those students who earn a grade of 4. Those students who earn grades of 5 on the Advanced Placement Studio Art Examination receive three credit hours for Art 7.

**Biology.** Four credit hours for EES 31, Introduction to Environmental/Organismal Biology, given to those who earn grades of 4 or 5.

**Chemistry.** Eight credit hours for Chm 21, Chm 22, and Chm 31 are granted to students who earn a grade of 5. Those students who earn a grade of 4, or who score 750 or higher on the SAT II chemistry subject test, are granted five credit hours for Chm 21 and Chm 22 and may apply to the department for a special examination that, if completed successfully, will result in an additional three credit hours for Chm 31.

**Computer Science.** Students receive four semester credit hours for CSc 11 for a grade of 4 or 5.

**Economics.** Students will receive three credit hours of ECO 11 for a score of 4 or 5 on the microeconomics exam and must complete ECO 22 at Lehigh to satisfy the degree requirements on the College of Business & Economics. Students will receive three credit hours of ECO 12 for a score of 4 or 5 on the macroeconomics exam and must complete ECO 21 at Lehigh to satisfy the degree requirements on the College of Business & Economics. Students receiving a score of 4 or 5 on both the microeconomics and macroeconomics exams will receive 6 credits for ECO 11 & 12 and satisfy the College of Business and Economics degree requirements.

**English.** Students who earn a score of 5 on one of the College Board Advanced Placement Tests in English (either in English Language and Composition or in English Literature and Composition) or who achieve a score of 750 or higher on the SAT II Subject Test in Writing receive six hours of Lehigh credit for freshman English (with exemption from the requirement). Students who receive a score of 4 or 5 on either of the Advanced Placement Tests in English or who have a score of 700 or higher on the SAT II Writing Subject Test will receive three hours of credit in freshman English; these students will complete the six-hour requirement by taking an English course suggested by the department, typically Engl 11.

**Government and Politics.** Four credits for POLS 1 are awarded to those students that score a 4 or 5 on the American Government test, and four credits for POLS 3 are awarded to those that score a 4 or 5 on the Comparative Politics exam.

**History.** Students earning a grade of 5 in the American History Advanced Placement examination will receive 4 credits for HIST 41, 44; students who receive a grade of 4 will receive 3 credits for HIST 41. Students earning a grade of 4 or 5 in the European History exam will receive four credits for HIST 12. Students receiving advanced placement in American history may not later enroll in History 41; students receiving advanced placement credit in European history may not later enroll in History 12.

**Latin.** Students receive three semester hours of credit for a grade of 4 or 5 in the Virgil examination; those who successfully write in more than one area (e.g., Virgil and lyric poetry) receive six hours of credit. Students receiving credit for Latin and who wish to continue their study of Latin must consult with the Director for proper placement.

**Mathematics.** Four semester hours of credit for Math 21, Calculus I, are granted to those who earn grades of 4 or higher on the Calculus AB examination. To those who earn a grade of 4 or higher on the Calculus BC examination, eight hours of credit are granted for Math 21 and Math 22, Calculus I and II. Credit for Math 21 and 22 or both may also be earned by passing the examination offered by the Mathematics Department during Freshman Orientation. Students regardless of whether they have taken the advanced placement examination may take this examination or not.

**Modern languages and literature.** Students receive four semester hours of credit at the intermediate level I for grades of 4, and eight hours of credit at the intermediate level I & II for grades of 5 on the advanced placement tests. Those who write the SAT II subject tests and score 600 to 699 receive four hours of credit; 700 and above receive eight hours of credit. The maximum number of credits given is eight. Those students receiving grades of 4 or higher on the French or Spanish literature examinations will receive 3 credits for French or Spanish 151.

**Music.** Three semester hours of credit for Mus 80 are given to those students who earn a grade of 3 or higher on the Advanced Placement test in Music, Listening/Literature of Music: Theory.

**Physics.** Four hours of credit are given for Physics 11, Introductory Physics I, for a grade of 5 on the Physics B examination or a grade of 4 on the mechanics section of the Physics C examination. If a student receives credit for Physics 11, four hours of credit will be given for Physics 21, Introductory Physics II, for a grade of 4 on the electricity and magnetism section of the Physics C examination. If a student wishes to be considered for credit for Physics 12 or 22, Introductory Physics Laboratory I and II, he or she should see the chairperson of the physics department with evidence of laboratory experience. A test is offered during Freshman Orientation.

**Psychology.** Three credit hours of Psych 2 are granted to students who earn a grade of 4 or 5. Students receiving credit may take Psych 2 for an additional credit at Lehigh without concurrent enrollment in Psych 1.

**Statistics.** Students scoring a 4 or 5 will receive 4 credits; for MATH 12 if enrolled in the College of Arts & Sciences or the College of Engineering & Applied Science, or ECO 145 if enrolled in the College of Business & Economics.

**International Baccaulaureate.** Students who earn the international baccalaureate may be granted credit in higher-level
or advanced subjects with scores of 5 or better. All students will have their credentials evaluated on an individual basis for specific course equivalency.

**Estimate of Expense for Undergraduates**
The operating expense of Lehigh University is supported principally by three areas of income: tuition and fees, endowment earnings, and gifts and grants. The university is conscious that educational costs are significant and it strives to maintain a program of high quality instruction while recognizing that there are limitations on what families can afford to pay. Costs will vary somewhat from student to student depending upon the various options chosen.

**Tuition, Room, and Board**
There are three major plans that cover the major expense associated with university attendance. These are as follows:

The **tuition plan**. The university provides comprehensive academic and student services under its tuition plan. The tuition sum is inclusive of most athletic events, basic treatments in the Health Center, libraries, and laboratory services. An additional $280 fee is charged to all students enrolled in the College of Engineering and Applied Science or with a declared major in natural science. The full-time tuition rate is charged to students enrolled in twelve or more credit hours per semester. For students enrolled in less than twelve credit hours, tuition is charged on a per-credit-hour basis.

The **residence halls plan**. A variety of living arrangements are available. The university provides housing for 2,000 students on or near the campus in a wide selection of housing facilities. The housing arrangements are grouped within four basic categories, with rates associated with the category level. Upperclass students contracting for residence halls housing will be required to submit a $200 advance deposit. This deposit is credited toward the room charge for the respective semester. The deposit is either full or partially refundable based upon the various options chosen.

The **board plan**. Eight board plans are available. Freshmen residents are required to participate in one of the Category I Meal Plans. Upperclass students living in residence halls are required to participate in one of the Category I or II Meal Plans. Subscription to special program meals is required of Taylor College students enrolled in less than twelve credit hours, tuition is charged on a per-credit-hour basis.

The **residence halls**. The university reserves the right at any time to amend or add charges and fees, as appropriate, to meet current requirements. Fees applicable to the 2000-01 academic year will be announced no later than January, 2000.

**Other Expenses**
A student should plan to meet various other expenses. These expenses include the purchase of books and supplies from the Lehigh University Bookstore located in Maginnes Hall. Necessary purchases supporting one's academic program should average approximately $500 per year. The Bookstore carries basic goods for students' needs. A student should also plan an allowance to handle personal and travel expenses.

**Plan of Payments**
An itemized statement of charges is mailed from the Bursar's Office approximately six weeks prior to the start of each semester. Payment is expected in full by the specified due date. Payment plans are available for those desiring extended payment arrangements.

Persons desiring a payment plan can elect participation in the university's educational payment plan which provides for the payment of tuition, room, and board over ten months. You may also elect to participate in the Richard C. Knight Plans. The university also offers a plan under which enrolled undergraduate students can pre-pay more than one year of
tuition at current rates. Complete information is available from the Bursar’s Office. Those persons desiring to use one of the plans must complete the necessary details no later than two weeks prior to the due date for payment.

Students attending the university under a provision with a state board of assistance or with financial aid from other outside agencies must provide complete information to the Bursar’s Office if assistance is to be recognized on the semester statement.

Refunds of Charges

Tuition. A student in good standing who formally withdraws (within the first eight weeks of a semester) or reduces his or her course enrollment below twelve credit hours will be eligible for a tuition refund. The refund schedule for student withdrawals and course adjustments is as follows:

<table>
<thead>
<tr>
<th>If the withdrawal occurs between</th>
<th>Refund</th>
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<tbody>
<tr>
<td>1st through 8th day of classes</td>
<td>90%</td>
</tr>
<tr>
<td>9th through 20th day of classes</td>
<td>50%</td>
</tr>
<tr>
<td>21st through 40th day of classes</td>
<td>25%</td>
</tr>
<tr>
<td>balance of semester</td>
<td>0%</td>
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</tbody>
</table>

The date used to calculate refunds is based on when a properly authorized withdrawal or drop/add is received by the Registrar’s Office.

In the event of the death of a student, tuition will be refunded in proportion to the semester remaining.

Tuition Credit/Suspension. A student who is suspended from the university for disciplinary reasons will be eligible for a tuition credit toward the semester immediately following the period of suspension. The amount credited will be based on the regular tuition refund schedule and calculated on the tuition rate in effect during the period of suspension.

The date used to calculate the tuition credit will be the date of the incident that resulted in the suspension. Under no circumstances will a tuition refund be provided to students who are suspended for disciplinary reasons.

Summer Sessions. Students who preregister for a summer session by the end of April will receive an invoice for their Summer Sessions.

Revised schedule by the end of April will receive an invoice for their Summer Sessions.

Refunds of Charges

Tuition. A student in good standing who formally withdraws (within the first eight weeks of a semester) or reduces his or her course enrollment below twelve credit hours will be eligible for a tuition refund. The refund schedule for student withdrawals and course adjustments is as follows:

<table>
<thead>
<tr>
<th>If the withdrawal occurs between</th>
<th>Refund</th>
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<tbody>
<tr>
<td>1st through 8th day of classes</td>
<td>90%</td>
</tr>
<tr>
<td>9th through 20th day of classes</td>
<td>50%</td>
</tr>
<tr>
<td>21st through 40th day of classes</td>
<td>25%</td>
</tr>
<tr>
<td>balance of semester</td>
<td>0%</td>
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</tbody>
</table>

The date used to calculate refunds is based on when a properly authorized withdrawal or drop/add is received by the Registrar’s Office.

In the event of the death of a student, tuition will be refunded in proportion to the fraction of the summer term remaining at the time of the death.

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The date used to calculate refunds is based on when a properly authorized withdrawal or drop/add is received by the Registrar’s Office.

Because of the short time involved, no refunds for tuition charged in the one-week workshops will be made after the first day of class.

In the event of the death of a student, tuition will be refunded in proportion to the fraction of the summer term remaining at the time of the death.

Residence hall refunds. Residence hall rooms are rented on an annual basis only. A student who signs a room contract is expected to reside in residence hall housing for both the fall and spring semesters of the specific academic year for which the contract was signed. A student who forfeits a room reservation and who returns to the university at any time during the contracted academic year is still obligated for housing rental charges if vacancy in the residence hall facilities exists and without regard to location. An advance deposit is required to hold a room. This deposit is non-refundable to entering freshmen and either full or partially refundable to upperclass students based upon specific criteria and a published refund schedule.

Prior to registration, housing rental refunds are made full in full in the event a student does not register because of illness, injury, or death; is dropped from the university due to academic reasons; attends a university-approved study abroad or co-op program; graduates; or voluntarily withdraws from the university. After registration, prorated housing rental refunds are granted based on separation from the university due to illness, injury, or death. In the event of voluntary withdrawal, a prorated refund is possible only with the provision that the lease can be transferred to another student for whom no other university accommodations exist. Prorated refunds are based upon the date the room keys are returned to the Office of Residential Services. Any student suspended or expelled from the university will not be granted any housing rental refund.

Refunds for board plans. Board plan refunds are made full in full in the event a student does not register for a specific semester and has not purchased any meals from the plan. Board Plan refunds after the start of the semester for students who register and/or purchase meals on a board plan but withdraw from the university will receive a board plan refund prorated on the number of unused weeks remaining on the plan. The Bursar’s Office is to be notified of the withdrawal by the Dean of Students Office of Academic Support.

Board plans may be changed within the requirements of the living area up to the tenth day of class of each semester at the Bursar’s Office with charges assessed per an established proration schedule.

Students who wish to change outside of the required board plan or after the tenth day of class for a reason such as a medical condition must petition and receive approval from the Office of Residential Services. If such changes are approved, adjustments will be processed on a pro rata basis as of the week following the last meal purchased.

Any student suspended or expelled from the university will not be granted a board plan refund. A student suspended may receive a prorated board plan credit based on the week following the last meal purchased which will be used toward the purchase of a board plan the semester immediately following the period of suspension. Such occurrences are to be documented by the Dean of Students Office of Academic Support and forwarded to the Bursar’s Office or Office of Residential Services.

Adjustments to financial aid. The Office of Financial Aid is responsible for determining the appropriate redistribution of charges and refunds when students are in receipt of financial assistance. These decisions are made on the basis of university, federal, and state agency regulations. Adjustment procedures, where financial assistance (including GSL and PLUS loans) is concerned, are on file in the Office of Financial Aid.

Financial Aid

The university is deeply committed to providing need-based financial aid. At least 50% of freshman classes now, and in the future, will receive financial aid awards.

Renewal of financial aid is based on continuing “need” and a minimum academic average of 2.00 (or as noted on the award notification. See below in section Renewal of aid). Students are also expected to advance at a rate of at least 12 credits per semester.

Lehigh expects each family to make every effort to pay tuition and other educational expenses. The aid program is designed to measure the dollar difference between the cost of attendance and the amount of money a family can be expected to contribute
towards those costs. That difference is called "financial need" and represents financial aid "eligibility." Most of Lehigh's funds are awarded on the basis of this "eligibility," the principal exceptions being explained below.

As noted, Lehigh currently enrolls at least 50 percent of the freshman class with university-funded scholarships ranging, according to need, from $500 to $28,000. An additional five to ten percent will enroll with aid from sources other than Lehigh, including state and federal grants, ROTC scholarships, aid from private sources, and education loans.

The basic forms of financial aid are employment, repayable loans and "gift aid," which is a non-repayable form of aid that can be called either scholarship or grant. Employment provides money for books and personal expenses, and is paid through bi-weekly payroll checks as students submit time sheets. Loans are borrowed dollars, from one or more resources, that are repayable at low interest rates after the student ceases to be enrolled on at least a half-time basis. Grants (or scholarships) are not repayable. Most are awarded on the basis of "need" and are renewable on the basis of continuing "need" and some stated minimum academic advancement criteria.

Additional sources of aid are state agencies, employers, and various clubs, churches, religious and fraternal organizations, and foundations. High school guidance counselors are able to provide information on local aid programs. There are databases of scholarship search organizations that can be accessed via the World Wide Web. Some examples are www.collegeboard.org, www.finaid.org and www.fastweb.com. Students are expected to apply for all possible kinds of outside financial assistance, especially the Pell Grant and state grants. Students are expected to take maximum advantage of outside sources to enable Lehigh to spread its own funds farther and to limit student borrowing.

**Application Procedures for 2000-2001**

The following instructions about filing for financial aid are addressed to prospective freshmen.

To be given proper consideration for financial aid, applications must be completed and ready for review by March 1, 2000. (Note: Students may be forced to use estimates in completing financial aid forms. Appeals based on extenuating circumstances may be submitted to the Committee on Undergraduate Financial Aid. Eligibility for financial aid is determined by calculating the amount a family can contribute to the cost of attendance based on income, assets, family size, number of dependents in college, and other factors. The expected contribution is then subtracted from the cost of attendance to arrive at "financial need.")

In general a student might be expected to have some need when the family's annual income and number of tax dependents
Several forms of university-funded aid, based on need and merit, are available.

**Sponsored scholarships.** Individuals, foundations, and corporations provide these funds through annual contributions to the university. Lehigh has 190 such sponsored funds.

**Endowed scholarships.** Income from invested gifts to the university makes these scholarships possible. The university has over 400 such funds, half of which are for general, unrestricted use.

**National Merit Scholarship program.** Scholarships ranging from $1,000 to $2,000 per year may be awarded to Merit finalists evaluated by the Department of Intercollegiate Athletics. Grants and theatre departments based on taped performances and membership of certain fraternities.

**Dean's scholarships.** Lehigh first began offering these awards to the class of 1999 in the annual amount of $7,000. Approximately 100 scholarships will be awarded to the class of 2004. Selections are made by the Office of Admissions based on academic excellence, and significant extra-curricular and leadership activities.

**Baker Gifted Arts Students Scholarships and Choral Arts Scholarships.** Awards are valued at $2,500 per year, renewable over four years. Selections are made by the faculty of the music and theatre departments based on taped performances and letters of recommendation. In addition to the scholarship portion of the award, Baker and Choral Arts scholars may receive music and acting lessons tuition-free.

**Army ROTC Leadership Awards.** In certain instances, the university may supplement an ROTC scholarship with a leadership award that can range for $3,000 up to the cost of room and board.

**Tuition Loan.** This award has the potential of being converted to a grant if the following conditions are met: 1) achieve the required grade point average for the award period as shown on the award notification; 2) pass 12 or more credits per award term, of which no more than four (4) credits (of the first 12 credits) may be from courses for which a grade was previously received. Any additional courses (above the 12 credits) may also be repeated courses; and 3) have no outstanding X or N grades. Any X or N grades must be removed prior to the end of the next semester and is the responsibility of the student to notify the Office of Financial Aid when all courses have been completed. If not canceled, the loan is repayable according to the terms for university tuition loans.

**President's Scholars Program.** This program provides an opportunity to receive fee tuition for a period of up to 12 months immediately following the awarding of the baccalaureate degree. A student may be declared a President's Scholar if, upon completion of 90 Lehigh credit hours, he or she has a cumulative GPA of 3.50 or higher at the end of any full-time fall or spring or full-time summer study (minimum 12 credit hours), or receives a Lehigh baccalaureate degree with High Honors or Highest Honors.

**Loan-Cancellation Awards.** This unique Lehigh award is used as an aid alternative for a student whose academic average is not sufficiently competitive for scholarship consideration. L-C begins as a loan, with the same terms as a regular University Tuition Loan. This award has the potential of being converted to a grant if the following conditions are met: 1) achieve the required grade point average for the award period as shown on the award notification; 2) pass 12 or more credits per award term, of which no more than four (4) credits (of the first 12 credits) may be from courses for which a grade was previously received. Any additional courses (above the 12 credits) may also be repeated courses; and 3) have no outstanding X or N grades. Any X or N grades must be removed prior to the end of the next semester and is the responsibility of the student to notify the Office of Financial Aid when all courses have been completed. If not canceled, the loan is repayable according to the terms for university tuition loans.

**High Honors or Highest Honors.** A student may be declared a President's Scholar if, upon completion of 90 Lehigh credit hours, he or she has a cumulative GPA of 3.50 or higher at the end of any full-time fall or spring or full-time summer study (minimum 12 credit hours), or receives a Lehigh baccalaureate degree with High Honors or Highest Honors.

**Availability of jobs**

Students may receive an employment allocation as part of their aid package. Pay rates range from the federal minimum wage to $7.00 per hour. Jobs are available throughout the university and are funded through federal, state, and institutional sources. Earnings from employment, other than work-study/work opportunity, will be included as “income” in calculating financial aid eligibility for the next year.

The Job Locator Development Program is designed to assist students who do not qualify under the Federal Work-Study Program to find employment off-campus or with a number of incubator companies located on the Mountaintop Campus. This program is coordinated through the Office of Career Services.

**Aid from the government**

Lehigh University is an eligible participant in federally funded student aid programs. Campus-based programs, where the university makes the awards based on the dollars available, include:
Three- and two-year scholarships are also available. Recipients
Federal Perkins Loans.
2000 to be considered on time. Returning students must file the
2. For freshman. The Free Application for Federal Student Aid
2365 to have information sent to Lehigh. Returning students
4. Submit the appropriate state grant application, especially if a
5. Submit signed copies of the 1999 IRS form 1040, including all
for one and notify Lehigh as soon as it is received.
available from the Office of Financial Aid.
Military Science for details.
Federal Stafford Loans, subsidized and unsubsidized, and
Federal PLUS Loans. Lehigh University can provide a list of
CollegeCredit, a part of the College Board, whose loan terms are
among the most competitive available.
Commercial loan programs. The Office of Financial Aid
provide a list of programs with current interest rates and terms and conditions of repayment.

Checklist for Financial Aid

1. For prospective freshmen. The completed CSS/Financial Aid
PROFILE Application must be received by CSS on or before
February 1, 2000 to be considered on time. Use CSS college code
2365 to have information sent to Lehigh. Returning students
must file by April 15, 2000.

2. For freshman. The Free Application for Federal Student Aid
must be received by the federal processor on or before March 1,
2000 to be considered on time. Returning students must file the
Renewal FAFSA by April 15, 2000. Lehigh's federal code is
003289. It must be used on the FAFSA if Lehigh is to receive the
information.

3. For returning students only. Submit the Lehigh University
Application for Undergraduate Financial Aid by April 15, 2000.

4. Submit the appropriate state grant application, especially if a
resident of Ohio, Massachusetts, Connecticut, Rhode Island,
Maryland, Delaware, Vermont, or West Virginia - states from
which Lehigh students have brought scholarships. Be guided by
the specific instructions. The FAFSA will be the basic form for
state grant consideration, but many states do require
supplemental applications.

5. Submit signed copies of the 1999 IRS form 1040, including all
pages, schedules and W-2s filed by the student and parent(s).
Non-filer's statements, for those not required to file a 1040, are
available from the Office of Financial Aid.

6. Check to be sure that the correct social security number is
listed on all forms. If a student does not have a number, apply
for one and notify Lehigh as soon as it is received.

7. Photocopy all forms filed for financial aid purposes.

8. Transfer students. Students must file a FAFSA and PROFILE
together with the Lehigh University Transfer Financial Aid
Application to be considered for university-funded aid. (The
Office of Admissions will send the Lehigh form.) File as close to
March 1, 2000 as possible. Transfer reviews are completed after
decisions are made for the freshman class (normally soon after
May 1, or earlier if the schedule permits). The federal
government requires all colleges, universities and graduate
schools to verify previous federal borrowing and to determine
that there is not a refund due the government for an over-award
of federal funds. Lehigh will check the Student Aid Report (SAR)
for data provided through the National Student Loan Data
Service (NSLDS). If, for whatever reason, that service does not
have a student's information on file, the student will be asked to
have any previous college(s) provide a Financial Aid Transcript.

Student Rights
Students have the right to know:
the cost of attendance;
the refund policy for students who withdraw;
the financial assistance available from federal, state and
institutional sources;
procedures and deadlines for submitting applications for
financial aid;
how financial aid recipients are selected;
how eligibility was determined, including all resources the aid
office considered available to the student;
how and when funds will be disbursed;
an explanation of each type of award received;
for any student loan received: the interest rate, total amount to
be repaid, when repayment begins, the length of the repayment
period, and the cancellation or deferment provisions of the loan;
for any Federal Work-Study or university-funded job: a
description of the job, the hours to be worked, the rate of pay,
and how and when the student will be paid;
the criteria used to determine satisfactory academic progress for
financial aid purposes; and
how to appeal a decision by the Office of Financial Aid
concerning any aid award.

Student Responsibilities
It is the student's responsibility to:
read directions thoroughly, complete all application forms
accurately, and to comply with any deadlines;
provide any supplemental information or documentation
required by the Office of Financial Aid or other agency if
applicable;
read, understand, and keep copies of any forms the student
is required to sign;
repay any student loans received;
attend an interview and set interviews if federal,
state or university loans are received while in attendance at
Lehigh;
notify the Office of Financial Aid of any change in enrollment
status or financial status (including any scholarships or grants
received from outside sources); changes of address and
enrollment status must also be reported to lender(s) for any
loan(s);
satisfactorily perform the work agreed upon in a Federal Work-
Study or university-funded work program; and
know and comply with all requirements for continuation of
financial aid, including satisfactory academic progress
requirements.

For more information write to William E. Stanford, Director,
Office of Financial Aid, Lehigh University, 218 W. Packer
Avenue, Bethlehem, PA 18015; telephone (610) 758-3181; FAX
(610) 758-6211.
Campus Life

Approximately 70 percent of all undergraduate men and women live on campus. Campus living facilities include traditional residence halls, apartments, suites in a multi-story building, or residence in fraternity or sorority houses. Physical facilities are also described in Section VI.

Residence Halls
The offices of Residential Life and Residential Services at Lehigh University are committed to providing quality housing and educational services to its resident students. Lehigh firmly believes that living in a residence hall allows students to become members of a special community, offering the opportunity to live with and learn from a diverse group of people. Efforts are made to integrate academic and out-of-the-class learning in order to enable students to develop a balanced and realistic approach to life after they leave the university.

Approximately half of Lehigh undergraduates live in university residence halls. The university has ten principal residence halls for undergraduate men and women. Most rooms are designed for two students, but a limited number of singles, triples, and 4-person suite and apartment units are available. Residence halls offer a wide variety of special live-in programs including: Taylor Residential College, ROTC House, Creative Arts House, Umoja House (African-American/Hispanic Culture), Impact Housing areas, traditional-style living (in buildings with corridors), and suite/apartment-style living.

To help facilitate and maximize a student's residence experience, approximately eighty staff members of the office of residence life live in the residence halls. On every hall there is a student staff member, a Gryphon, who provides assistance in personal and academic matters, refers students to other offices where appropriate, helps mediate conflicts, and develops educational, social, and recreational programs. In addition to the student staff, five professional Residence Life Coordinators live in the residence halls thus providing additional resources for students.

In every residence hall there are also House Councils that are part of the larger Residence Hall Association. Participation in the Residence House Council provides a chance to develop leadership, programming, human relations, and budgeting skills. It is a vital and active organization, whose prime focus is to help fund residence hall programs, to assess students' opinions on issues affecting them, and to develop many service-oriented programs to aid resident students in their stay on campus.

When a candidate accepts an offer of admission to the freshman class, the candidate is sent a Room and Board Application-Contract. Those desiring accommodation in the residence halls must return this application-contract promptly. Priority for assignment is based on the date the candidate accepts an offer of admission to the university residence halls. The university has ten principal residence halls for undergraduate men and women. Most rooms are designed for two students, but a limited number of singles, triples, and 4-person suite and apartment units are available. Residence halls offer a wide variety of special live-in programs including: Taylor Residential College, ROTC House, Creative Arts House, Umoja House (African-American/Hispanic Culture), Impact Housing areas, traditional-style living (in buildings with corridors), and suite/apartment-style living.

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Currently, all freshmen and sophomores are guaranteed housing on campus. Although juniors and seniors may not initially be guaranteed housing, in the past there has been sufficient space available to meet the needs of all students who desire residence hall housing. The Office of Residential Services uses a lottery to provide for fair and equitable distribution of available housing among upperclass students. The lottery is scheduled early in the spring semester. Students who are guaranteed housing pay a $200 deposit to hold the space for the following academic year.

Fraternities and Sororities
The university has one of the strongest Greek systems in the nation. The continued strength of this system is due in part to the efforts of the Interfraternity Council, Panhellenic Council, the Greek Alumni Council, the Office of Residential Services and the Office of the Dean of Students to improve the quality of fraternity and sorority life through membership, leadership, social, educational, housing, and financial management training.

Greek life is an attractive alternative among the residence options at Lehigh. Each fraternity or sorority is like a close-knit community. These groups determine their own goals; organize their own houses and business affairs with the assistance of the Office of Residential Services; conduct their own social, philanthropic, and athletic activities; assist with planning their own meals; and select their own membership. Because they are largely self-governing, these organizations offer numerous opportunities for student involvement and leadership.

The twenty-eight fraternities and eight sororities form a larger Greek community comprising approximately 42 percent of the undergraduate population at Lehigh. Through the Interfraternity Council (I.F.C.) and the Panhellenic Council, they determine policies and organize social, philanthropic, and educational activities for the Greek community as a whole.

There are eight sorority chapters at Lehigh. Six are housed in the Centennial I complex on the Asa Packer Campus and two are located in Sayre Park. The sororities are Alpha Chi Omega, Alpha Gamma Delta, Alpha Omicron Pi, Alpha Phi, Delta Gamma, Gamma Phi Beta, Kappa Alpha Theta, Phi Beta Phi.

Twenty-five of the fraternities are located on campus in Sayre Park. The remainder are located near the campus. The fraternities are Alpha Chi Rho, Alpha Sigma Phi, Alpha Tau Omega, Beta Theta Pi, Chi Phi, Chi Psi, Delta Chi, Delta Phi, Delta Sigma Phi, Delta Tau Delta, Delta Upsilon, Kappa Alpha, Kappa Sigma, Lambda Chi Alpha, Phi Delta Theta, Phi Gamma Delta, Phi Kappa Theta, Phi Sigma Kappa, Pi Kappa Alpha, Psi Upsilon, Sigma Alpha Mu, Sigma Chi, Sigma Nu, Sigma Phi Epsilon, Theta Chi, Theta Delta Chi, Theta Xi, and Zeta Psi.

Religious Activities
The Religious Program is under the general supervision of the university chaplain. The chaplain participates in the ceremonial life of the University and conducts special university worship services throughout the year. All worship services are interdenominational, with some being inter-religious. Roman Catholic masses are held regularly. The Newman Center can be contacted for a schedule of services.

Lehigh University is non-denominational. Packer Memorial Church, dedicated in 1887 in honor of the University's Founder, Asa Packer, continues to be the center for campus worship services.

The University Chaplain works with representatives of campus religious groups of all faiths and assists students in planning religious life programming. The chaplain's office sponsors an Oxfam Fast in November, organized the original Community Service Desk that helps coordinate volunteer services on campus, and creates opportunities for discussion of moral and spiritual issues through the Chaplain's Forum. In addition to providing pastoral counseling, supporting religious groups, and helping bring speakers to campus, the chaplain seeks to provide leadership to the university on religious and ethical issues.

Over fifteen religious groups on campus provide opportunities for religious fellowship. The groups include the Newman Association for Roman Catholic students under the guidance of a resident priest; the Jewish Student Center, which sponsors various activities for Jewish students; and organizations for Hindu and Moslem students. A variety of Protestant Christian organizations are available to students, including the Lehigh Christian Fellowship, Navigators, and the Fellowship of Christian Athletes.

The chaplain's office makes information about religious life available to all students in the Fall and can be contacted at any time for information about worship opportunities and religious activities either on campus or in the local Bethlehem community.
Student Organizations
Lehigh offers a wide field of extracurricular activities and student organizations. There is a campus radio station, a twice-weekly student-run newspaper, a dramatic club, musical organizations, and many other opportunities for participation. Course societies promote intellectual interest in various fields of study and develop professional spirit among students.

Interest and hobby groups include art, dance, band, chess, cultural groups, computer, languages, rugby, sailing, skiing, bowling, Taekwondo, crew, political clubs, fencing, and volleyball. These are described in the Lehigh Handbook, which is distributed to all students.

Many students also are elected to honorary societies and others join course societies.

Lehigh University Theatre
In Spring, 1997, the department of theatre moved to the Zoeller Arts Center. Lehigh University's impressive new performing arts facility. Three theatres, scene and costume shops, a dance studio, music practice rooms, classrooms and more enhance the department's curricular activities. The department of theatre's annual production program includes four mainstage productions, now produced in the three-hundred-seat Diamond Theater and four or more lab productions in the one-hundred-seat Black Box Theater. The plays range from classics to world premieres and recent mainstage seasons have included The Comedy of Errors, Spunk, Who's Afraid of Virginia Woolf?, The Three Penny Opera, Fences, Godspell, Speed-the-Plow, A View from the Bridge, Curse of the Starving Class and A Raisin in the Sun.

Shows directed and produced by students as class projects or independent work occur regularly in the Black Box Theater. Recent lab theatre productions have included Baby with the Bathwater, A Black Woman Speaks, The Blue Hour: City Sketches, The Philadelphia, Talk to Me like the Rain and Let Me Listen, This Property is Condemned, Variations on the Death of Trotsky, A Wife for a Life, Spoon River Anthology, 'night Mother, Widows and Children First, and a reading of a student-written play, The Last Market Economy. Many events are sponsored by the Mustard and Cheese Drama Society, the country's second-oldest collegiate drama club.

Auditions and production crews are open to all members of the university community. Production opportunities exist in performance, choreography, set and costume construction, properties management, lighting, sound, house management and publicity. Advanced students have opportunities to direct or design, under faculty supervision.

Outstanding work in the mainstage or lab theatre seasons may be recognized with Williams prizes and theatre department prizes in acting, directing, design, and technical production.

Professional guest artists — directors, playwrights, designers, and actors — frequently visit the Lehigh campus to work on mainstage productions, teach classes, and conduct seminars and workshops for all interested students. The department also sponsors artists-in-residence, guest lecturers, workshops, and touring performances. Recent guests have included Roscoe Lee Brown, Tony Zerbe, Edward Albee, Touchstone Theatre Ensemble, Jay O'Callahan and Pilobolus Dance Company.

Musical Organizations
The university sponsors both a variety of student musical organizations that give performances on and off campus and several professional concert series which bring visiting artists to the campus. The choruses, bands, orchestra, and ensembles are conducted by members of the faculty and managed by elected student leaders. Nearly all performances, except Christmas Vespers, are held in Baker Hall in the new Zoeller Arts Center.

Choral Arts is comprised of three choral organizations: University Choir, Overtones and Choral Union. The University Choir tours regularly — recent trips have taken the choir to Asia, France, Canada; Germany; Puerto Rico; the Virgin Islands; Washington, D.C.; California and Florida — in addition to performing several traditional concerts on campus including Christmas Vespers. The Overtones is a select small group performing jazz and popular arrangements that performs in a variety of settings each year. The Choral Union, formed in 1985, performs major works with orchestra. It is open to all students, faculty, and staff as well as members of the community.

The Lehigh University Philharmonic has won a large following for its performances; this group also tours. A strong program of chamber music ensembles has emerged, including groups of string, brass, woodwind, percussion and mixed instruments. A variety of performing opportunities exists for these players.

Another recently formed program is the Scenes from Opera and Musical Theatre, which rehearses short segments to be performed in full costume with lights and a stage setting. In January 1997 they presented their first full-length musical, Into the Woods, and in January 1998, A Little Night Music was performed.

The Jazz Ensemble plays concerts on campus, at festivals, and frequently tours in the spring. The Jazz Band performs jointly with the Jazz Ensemble and its own concert at the end of the year.

The Lehigh University Very Modern Ensemble (LUVME) combines students, faculty, and professional musicians who perform the music of the 20th Century. LUVME also sponsors concerts of music by Lehigh student composers and regularly commissions works from nationally and internationally renowned composers.

The Wind Ensemble plays several concerts on campus during the spring and often tours (Florida, Montreal, New Orleans, Boston, San Francisco, Bermuda, etc.). The Symphonic Band, which performs on campus in the spring, is open to students, faculty, and staff as well as members of the community.

The "97" marching band is widely known for its imaginative and spirited performances on the gridiron and in the stands in support of the Lehigh football team. Pre-game and half-time performances are precision drills with a varied repertoire of classical music to traditional fight songs. Nine students serve in executive positions.

Private instrumental and vocal lessons with instructors approved by the music department are open to all students. The cost of lessons is in addition to tuition expense. Students have the opportunity to perform in noon recitals or in a senior recital.

Volunteer and Community Services
Lehigh's Community Service Center, located in the Ulrich Student Center, is an information center for students, faculty, staff, student organizations and Greek letter groups who are interested in volunteering in the community. The Center is staffed by students who serve as Community Service Assistants, and is overseen by Lehigh's Community Service Coordinator, a member of the Dean of Students Office.

Students are involved in a wide range of service programs. Some of the projects include tutorial programs in local schools such as America Reads, and mentoring programs such as S.T.A.R., and Big Brothers/Big Sisters. Students are also active in local hospitals and with environmental groups. Students travel around the country over the spring break with the Alternative Spring Break Program to participate in Habitat for Humanity projects. Service learning courses are being integrated into the Lehigh curriculum.

Part of the Lehigh experience is getting involved. If you want to work in the community, contact the Community Service Center at (610) 758-4583 or check out the Center's web page at http://www.lehigh.edu/~service/center.html.

Guest Speakers
Students have the opportunity to hear a wide variety of notable speakers. The speeches are offered free of charge. Many of the speakers appear under the auspices of the Visiting Lecturers Committee. Committees with access to special funds and academic departments regularly offer presentations by scholars from various disciplines. In addition to delivering a formal address, the speakers
are often invited for brief residencies to provide opportunities for more informal interaction with students.

Among those to visit the campus have been former President of Poland, Lech Walesa; poet laureate, Robert Pinsky; attorney F. Lee Bailey; Lee Iacocca; philosopher Derek Parfit; General Colin Powell; South Africa’s Bishop Desmond Tutu; and novelist John Irving. Thomas Armstrong, director of the Whitney Museum, spoke with students during a week-long residency. An Engineering Expo with speakers representing many prominent industries featured Peter Bridenbaugh, vice president of science and technology, Alcoa. From art to engineering, the campus stays in touch with current issues, trends, and movements through its many and varied speaker series.

**Athletic Opportunities**

Students can participate in many intercollegiate, recreation, and intramural athletic programs.

Intercollegiate, varsity-level sports include the following. FALL: football, men’s and women’s cross-country, men’s and women’s soccer, women’s field hockey, women’s volleyball and men’s and women’s tennis. WINTER: Men’s and women’s basketball, wrestling, men’s and women’s indoor track and men’s and women’s swimming. SPRING: Baseball, tennis, golf, men’s and women’s outdoor track, men’s and women’s lacrosse and softball.

Athletic facilities are located in Taylor Gymnasium and Grace Hall and on the Murray H. Goodman campus, which is located one and one-half miles south of the main campus. The 500-acre Goodman athletic complex includes Stabler Arena, which seats 6,000 and hosts all Lehigh basketball games and several wrestling matches. The campus also contains the Philip Rauch Indoor Tennis Center, which includes a one-eighth-mile track and indoor tennis and basketball courts. Goodman Stadium is a 16,000 seat stadium for football, soccer and lacrosse. The four-court Lewis Indoor Tennis Center was completed in 1994. Other facilities on the campus include a championship cross-country course, baseball and softball fields, outdoor tennis courts, lacrosse and field hockey fields, and a new all-weather, nine-lane, outdoor 400-meter track.

Lehigh is affiliated with the National Collegiate Athletic Association (NCAA), the Patriot League and the Eastern Intercollegiate Wrestling Association (EIWA). Lehigh frequently hosts collegiate championship events in men’s and women’s sports and is the summer training camp facility of the Philadelphia Eagles.

**Intramural/Club Sports**

The Department of Intramural & Club Sports supervises some 20 intramural and 20 recognized club sports. The aim is to ensure the health and physical development of students while participating in various levels of competition. ALL PARTICIPANTS ARE RESPONSIBLE TO SUPPLY THEIR OWN APPROPRIATE INSURANCE COVERAGE.

Through its program of intramural sports, the university endeavors to maintain among its students a high degree of physical fitness, to establish habits of regular and healthful exercise, to foster the development of such valuable byproducts as self-confidence, good sportsmanship, and a spirit of cooperation, and to provide each student with ample opportunity for acquiring an adequate degree of skill in sports of the type in which participation can be continued after graduation.

Club Sports are oriented toward mutual interest and physical activity. The underlying purpose of any club is to join together those members of the student population that share a common activity interest. Club competition can range from a club varsity status (Crew or Ice Hockey), Club Competitive (Ski Team, Men’s Volleyball, Lacrosse, Rugby, etc.) to Club Developmental (Soccer, Gymnastics, Taekwondo, etc.). Students are encouraged to pursue their special interests.

**Good Citizenship**

The university exists for the transmission of knowledge, the pursuit of truth, the development of students, and the general well-being of society. Free inquiry and free expression are indispensable to the attainment of these goals. All members of the academic community are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth.

Out of concern for individuality and respect for the privacy of all persons, the university does not impose a common morality on its members. Institutional existence, however, is a privilege granted by public trust, subject to the sanctions and responsibilities defined by society. For this reason, the university has a responsibility to establish standards of conduct appropriate and applicable to the university community.

Lehigh accepts its responsibility as an institution within the broader social community. The standards of behavior expected of its members are those that the university regards as essential to its educational objectives and to community living.

Lehigh relies primarily on general principles and statements of expectation for standards of conduct, and assumes that those admitted to the university community are capable of accepting this responsibility. Specific regulations are kept to a reasonable minimum and are published in the Lehigh Student Handbook. Students are responsible for knowing the procedures, regulations and rules of conduct as published in the Handbook.

In accordance with these purposes and objectives, disciplinary action will be taken when necessary to protect the academic integrity of the university and the welfare of its members.

All members of the university community are subject to municipal, state, and federal laws. The university is not a sanctuary for persons who violate these laws. Lehigh is concerned, however, about the rights of students as citizens and will direct them to legal counsel when necessary. Off-campus misconduct may be the basis for disciplinary action.

Further, the university as a part of the community has an obligation to report serious crimes to civil authorities.

**Policy on Dissent**

The university faculty has a policy on dissent that emphasizes the responsibility of all members of the university community. The guidelines adopted broadly set forth the following acceptable forms of dissent on campus:

1. Free inquiry and free expression, including the right to open dissent, are indispensable in achieving the goals of an academic community.
2. Coercive activities employed by individuals or groups either to repress legitimate dissent or to demonstrate dissent are a threat to the openness of the academic community and will be dealt with as an extremely serious matter.
3. Where physical coercion is employed or physical obstruction persists and the university is prevented from resolving the matter through its established disciplinary procedures, legal sanctions will be employed.

This statement provides that orderly and peaceful demonstrations on campus are not forbidden unless they interfere with legitimate university functions. The authority for making the initial judgment in determining the permissible limits of protest rests with the president and counsel of an advisory committee consisting of four faculty members and four students.

Conduct that exceeds permissible limits will be met with university sanctions ranging in severity from admonition to expulsion, or in cases of aggravated or persistent violation of defined rights, with civil arrest and prosecution under an appropriate charge. Prime authority for discipline rests with the faculty and the university committee on discipline.
II.

University Resources

A student enrolled at an institution of the size and tradition of Lehigh can draw upon many resources to enhance the educational experience. These range from classrooms and laboratories with modern equipment to expert faculty members and extensive library collections. Indeed, Lehigh University’s 1,600 acres comprising its three Bethlehem campuses are a special resource, providing a beautiful environment for learning. Following are descriptions of various resources related to academic programs.

Information Resources

The exponential growth and increasing sophistication of information technology offer new and exciting opportunities for enhanced teaching, learning, and research. At the same time, these changes blur traditional boundaries between previously distinct academic functions such as library reference and computer consulting services. At Lehigh University, one merged organization called Information Resources (IR) delivers communications, computing, library, and media services to capitalize on these new opportunities. IR services are provided by cross-functional teams organized to support each of the major disciplines and courses of study with the most advanced technology and the most appropriate scholarly resources. These teams facilitate an integrated approach to computing, information retrieval, and the use of instructional technology. Additional information about Information Resources, its mission, its organizational structure, and its staff can be found on the IR home page at http://www.lehigh.edu/ir.

Libraries

Two major facilities, the Fairchild-Martindale Library and the Linderman Library, house the university collection of more than one million volumes. The Fairchild-Martindale Library contains books, journals, newspapers, audio-visual resources, and microform collections in all branches of science, engineering, mathematics, and the social sciences, including business and education. Subscriptions to more than 7,000 journals and serials allow the university to compete successfully with many larger institutions in supporting scholarly research. A government depository since the 19th century, the Fairchild-Martindale Library also contains more than 500,000 federal, Pennsylvania, and United Nations documents, as well as a large collection of technical reports from governmental agencies.

The historic Linderman Library with its stained glass skylight, spiral staircase, and gothic detailing evokes the classic collegiate atmosphere of the late nineteenth century. Appropriately, it houses books and journals in the humanities and Lehigh’s impressive collection of rare books. A complete four-volume set of the original folio edition of James John Audubon’s Birds of America enhances studies in biology, botany, art, and publishing history. In the elegant Bayer Galleria of Rare Books students can examine original editions of important works in science and technology such as Darwin’s Origin of Species. Other strengths of these Special Collections, numbering some 25,000 volumes, are travel and voyages, 19th century bridge construction, and English and American literature. In addition more than 30 separate archival collections focus on industrial and regional history.

The “virtual electronic library” at Lehigh is just as important as the print-based one. Lehigh has available a full range of electronic indexes, reference works, full-text databases, and image databases, all of which are accessible to Lehigh students and faculty from any computer on campus (including those in the residence facilities) or off-campus via modem. A single Web-based interface allows the student to move seamlessly from Lehigh’s own online catalog (named ASA after Lehigh founder Asa Packer) to databases of citations, abstracts, articles, or book reviews to the full text of many of these resources. The Lehigh virtual library also identifies for students the most important scholarly and governmental Web sites and connects them easily to these sites to and collections in other libraries, throughout Pennsylvania and around the world. There are easy ways to borrow books from other academic libraries including direct borrowing from other academic libraries in the Lehigh Valley, and interlibrary loan for use of collections throughout the world.

Networking and Voice Communications

Lehigh University is a “wired” campus in every sense of the word. A high-speed fiber optic backbone network ties together all major classroom and administrative buildings, the libraries and the computing center, the new Zoellner Center for the Performing Arts, and all student residences, including fraternities and sororities. This same extensive wiring plant and associated networking hardware and software connect the university to the global resources of the World Wide Web. Electronic communication is a way of life for students, faculty, and staff at Lehigh. Student computer use in the residences is supported by the World-Wide Information Resources in Every Dorm (WIRED) program described under Residence-based Services. Many students take advantage of this program to connect their microcomputers to the campus system via the high-speed backbone. A sophisticated digital telephone system managed by Information Resources supplies telephone, voice-mail, and some ancillary data services to the entire campus, including residence facilities.

Computing

Information Resources provides computing services to all university departments and research centers, serving the needs of students, faculty, and administrative users. A variety of computing facilities are available: an Information Commons at the Fairchild-Martindale Library, a large site at the Fairchild-Martindale Computing Center, many additional decentralized computing sites with workstations or microcomputers, computer classrooms, computer-equipped lecture rooms, and related printing and plotting devices. Information Resources offers the latest technology to all students and faculty across the entire campus.

The Fairchild-Martindale Computing Center houses a multiprocessor Silicon Graphics compute server and several IBM RISC System 6000s configured for campus communications including electronic mail, campus-wide electronic bulletin boards, the World Wide Web and file storage. The computer server provides computing cycles for compute-intensive applications, including a variety of programming languages, mathematical and statistical software packages, and graphics packages. The capacity represented by these machines is constantly being increased to meet the escalating demand. Lehigh University is a founding member of Internet2, the new national research and education computing network, and qualified Lehigh computer users may apply for access to resources at national supercomputing centers.
More than 400 microcomputers (primarily IBM-compatible personal computers) are distributed across campus for convenient use by Lehigh students at 23 computing sites. For example, there are 70 microcomputers in Linderman and Fairchild Libraries; 70 in Rauch Business Center, and 30 at Grace Hall. Local and wide area networking solutions are in place to give students and faculty access to site-licensed software applications and central file space from the campus sites or their residence facility. The software available includes word processing, spreadsheets, database managers, presentation and graphics software, programming languages, mathematical and statistical packages, and more specialized applications for engineering, scientific publishing, and creative writing. With the assistance of the faculty, Information Resources reviews and adjusts its software licenses frequently to meet the instructional and research needs of students and faculty.

In addition to the microcomputers at distributed sites, Information Resources maintains more than 60 Silicon Graphics workstations at 11 campus sites. They are also connected to the campus backbone and the central file space; as a result, a single user can perform high intensity computing using the resources of several workstations simultaneously. In addition to most of the software available through the PC sites, the workstation sites offer mathematical, statistical, graphics, and document authoring applications specifically designed for a workstation environment. In cooperation with the Department of Mechanical Engineering and Mechanics, Information Resources also operates the Computer-Aided Design (CAD) Laboratory.

Providing technology to support classroom teaching, laboratories, and other aspects of the academic program is a strategic priority for Lehigh University. Information Resources provides technical support for an increasing number of fully-equipped classrooms, suitable for "hands-on" computer instruction. Each computer classroom has networked microcomputers or workstations and a large-screen projection system connected to an instructor's station. Other classrooms are equipped with permanently-installed computer projection systems. In addition portable microcomputers and portable computer projectors are available through Information Resources to enable faculty or students to give computer-based presentations in any classroom.

Media Services
The Instructional Technology Support Service operates three facilities to provide students with access to and instruction in a wide range of traditional and high-tech media resources: the International Multimedia Resource Center or IMRC, the Media Production Center, and the Media Center.

International Multimedia Resource Center
The IMRC, located in Maginnes Hall immediately adjacent to the Fairchild-Martindale Library and Computing Center, supports faculty and staff in the design and production of multimedia presentations and projects in cooperation with the College of Arts and Sciences and the Modern Language and Literature department. Emphasis is placed on enriching student learning through the use of a variety of interactive multimedia resources. The facility also sponsors business, university, and international broadcasting and teleconferencing events through satellite and videoconferencing technologies.

The World View Room, a comfortably furnished facility accommodating about 25, features diverse cultural programs on wide screen television. These regularly scheduled domestic and international programs are derived from SCOLA (a multi-university consortium that transmits foreign news broadcasts); the International Channel; and selected cable and satellite broadcasts. Domestic and satellite dishes are mounted atop Maginnes Hall. The IMRC also coordinates the programming on several Lehigh channels of the campus cable network, one of which features international news and cultural events, as well as university academic and athletic programs.

Media Production Center
The Media Production Center in Linderman Library offers students and faculty consulting assistance, instruction, and a wide range of modern and traditional technology for the creation of high quality audio, graphical, or video resources for classroom presentations, projects, and portfolios. Students can scan and edit text, photographs, and slides, and these images can be output to standard laser printers, color printers, or to computer files for transfer and manipulation. Video cameras, a small video studio, and both entry-level and professional editing equipment facilitate the production of audio and video material to support the academic program. Students are introduced to the new world of digital imagery through the use of digital cameras, a photo-quality printer and image-manipulation software, and a photography studio that accommodates both traditional and digital cameras. With these facilities and instruction, Lehigh students develop the skills they need to make high quality graphical presentations required in today's business environment.

Media Center
The Media Center in Fairchild-Martindale Library offers media resources and a basic production facility (scanners, color printers, facilities for making transparencies). Resources include audio, video, and electronic media and the equipment and viewing spaces needed for their use. More than 25,000 units, including audio cassettes and CDs, videos, slides, and related materials are available. The Center also coordinates the rental of films and videos for classroom use. A limited supply of laptops for short-term rental by students, faculty or departments is housed there as well. The Media Center is also home to the Education Curriculum Library, developed in conjunction with the School of Education to afford teachers an opportunity to examine K-12 textbooks, software and auxiliary teaching materials.

Student Services
The libraries, Information Commons, and most distributed computing facilities are open seven days per week and for extensive evening hours during the fall and spring semesters. For most of these hours, a help desk located at the Fairchild-Martindale Library provides general help for students and faculty on-site and for telephone inquiries relating to both library research and computing. Help desk staff refer difficult or more specialized questions to experts as needed. There are also help desks located at the Linderman Library and at some distributed sites. The campus telephone operators answer questions about general campus activities whenever possible.

Students may also take advantage of virtual help desks where they enter the questions or problems relating to library research, computing hardware or software, or telecommunication at any hour of the day or night for response at a later time, usually within one working day. Most library and computing services are available electronically; for example, requests for books to be recalled, film rental requests, frequently asked question (FAQ) files, and seminar registrations. Each semester Information Resources' Client Services Group offers an extensive program of seminars and course-based instructional sessions for students. Attendees learn to use software applications, the extensive print and electronic library resources, and the World Wide Web. Students learn how to create their own "home pages" as part of seminars on authoring documents for the Web. In class sessions, IR staff work closely with faculty, to integrate library, computing and media resources into the curriculum. IR computing, information retrieval, and instructional technology consultants have been instrumental in facilitating recent course projects in a wide range of disciplines using interactive Web sites created by faculty and students.

Online and printed guides and manuals for computing and library resources are provided for students. These are issued in a
variety of formats: user manuals, user guides, and shorter tip sheets. Most seminars also include handouts that students can consult as needed. Through seminars and policies on use of print and electronic resources, students are taught computer ethics, recommended computing practices such as frequent backup and password changes, and an understanding and respect for state and federal laws governing copyright, privacy, and destruction or vandalism of library resources or computer systems, networks, databases or software.

Information Resources maintains a variety of facilities for printing, copying, and duplicating within the constraints of copyright legislation. In the libraries, public photocopi ers and microform printers are maintained for convenience in copying print or microform resources. The Media Production Center (described under Media Services) can duplicate audio and video resources. For computer printing at central and distributed sites, a network of PostScript laser printers is provided. In addition, larger printing or plotting jobs can be routed electronically to the multiple PostScript laser printers and publication-quality multi- pen plotters at the Fairchild-Martindale Computing Center.

Residence-based Services
The World-Wide Information Resources in Every Dorm or WIRED program is designed to provide high-speed network connectivity and to assist Lehigh students with the use of computer hardware and software in the residence facilities. Participants in the WIRED program receive both voice mail and a data connection to the campus high speed backbone. WIRED staff communicate with students well in advance of their arrival at Lehigh to identify for them compatible hardware and software for use on the campus network. When students initially bring their computers to campus, WIRED staff assist them in obtaining and installing the necessary network interface cards and network software. Throughout the semester the WIRED staff provide continuing assistance. The front line WIRED consultants are well-trained students who live in the residences and can readily provide prompt, on-site assistance. The consultants are supported by expert computing staff who supervise the program and assist with more difficult problems.

Student Employment
Student assistants are essential for the operation of most Information Resources services. Working for IR, students gain valuable skills and essential work habits. At the job fair held each fall there are opportunities to learn in-depth about the jobs available.

Art Galleries - Museum Operation
The Lehigh University Art Galleries maintain and develop the university’s permanent art collection, and present temporary exhibitions designed to make visual literacy a result of the university learning experience. More than twenty exhibitions a year in seven campus galleries introduce students and the community to current topics in art, architecture, history, science, and technology. The exhibition schedule is supplemented by lectures, films, workshops, and research opportunities in the permanent collection. The art galleries play an important role in the educational mission of the university through its exhibitions and programs. The galleries occupy exhibition, storage, office and workshop space in several campus locations. The Upper Gallery and Lower Gallery permanent exhibitions are in the Zoellner Arts Center. Maginnis Hall houses the DuBois Gallery, the Girdler Student Gallery is in the University Center, and the Siegel Gallery is in Iacocca Hall on the mountaintop campus. The Muriel and Philip Berman Sculpture Gardens are located in the courtyard of Mudd, Mart, Whitaker and Sinclair buildings; and on the mountaintop campus, and Saucon Fields on the Murray H. Goodman campus. The Ralph L. Wilson Study Gallery and Open Storage facility is located in Building J, mountaintop campus and available by appointment. LUAG offices are in the Zoellner Arts Center.

Exhibitions
Exhibitions and gallery events are scheduled to supplement formal classroom study in the visual arts, to create educational opportunities for the entire student body, and to enrich the cultural life of the campus and the community at large. The annual schedule includes the exhibition of works from the permanent collection, the use of borrowed objects, and traveling exhibitions on loan from major museums and cultural institutions. Experts in various fields serve as guest curators of special project exhibitions. Interdepartmental projects within the university encourage increased involvement by faculty and students. Undergraduates may take advantage of courses in museum studies including internship and independent study in the collection.

Collections
Lehigh University’s permanent art collection is a work/study collection intended as a resource for students pursuing formal study in the visual arts and/or museum studies, for the faculty, and for interested members of the community. Each year, several exhibitions are prepared from the collection and works are loaned to major museums throughout the nation.

The permanent art collection consists of a variety of works by old masters and contemporary artists: Important collection groups include: the Marion B. Grace Collection of European Paintings (Gainsborough, Reynolds, Goya, Hobbema, Hoppner, and others); the Dreufus Collection of French Paintings (Bonnard, Sisley, Vuillard, Courbet); the Ralph L. Wilson Collection of American Art (paintings by Prendergast, Sloan, Henri, Lawson, Bellows, Davies, Burchfield; prints by Whistler, Hassam, Motherwell, Johns, Rauschenberg, Calder, Warhol); the Prasse Collection of Prints (Delacroix, Matisse, Renoir, Kent, Kunyosy, Rivera); the Philip and Muriel Berman Collection of Contemporary Sculpture (Kadishman, Unger, Tumarkin, Bertoia, Shaw).

Also, the Farnside Collection of European Old Master Prints and Drawings; the Baker Collection of Chinese Porcelains; the Langermann Collection of Pre-Columbian Art; the Mr. and Mrs. Franklin H. Williams African Collection (gold weights of the Akam and West African objects); the Lehigh University Photography Collection (Fox-Talbot, Fenton, Jackson, Atget, Kasebier, Brandt, Siskind, Hahn, Clark, Martinez-Canas, Serrano); and the Lehigh University Contemporary Prints Collection (Bearden, Rivers, Anusziewicz, Soto, Roth, Chryssa, Ruchsa, Tobey, Calder, Kitaj, Marella-Reli, Genoves, Cruz Azaceta, Golub, Jimenez, Piper, Serrano, Simpson), and the Philatelic and Numismatic collection.

Faculty Development and Learning Innovations Program
Faculty interest in teaching led to the establishment of this program in 1989. Faculty Development & Learning Innovations Program connects professors with resources on teaching and learning. These include 1) faculty-led workshops on such topics as preparing a Teaching Portfolio. The Program co-sponsors sessions of the Teaching & Learning Technology Roundtable.

The Program funds faculty trips to teaching conferences such as the Lilly Conferences on College Teaching and annual American Association of Higher Education conferences on such topics as case studies, assessment and evaluation, and the quality of the academic environment. At monthly faculty development lunches, faculty give reports from these conferences, or discuss other aspects of teaching.
Dr. Dina Wills, Faculty Development Director, provides confidential, voluntary consultation to faculty about their teaching, which may include videotaping of class sessions and classroom observation visits, with discussions about what these observations show. Informal mid-semester evaluations in classes can be done by Dr. Wills, or by teams of faculty who visit each other's classrooms and speak to each other's students, using questions provided by the teacher of the class. Both the Library and the Faculty Development and Learning Innovations Program have books and videos on many topics related to teaching. Policy for the program is set and guided by a nine-member Faculty Development Council, with representatives from all four colleges. The Faculty Development and Learning Innovations Program is located in room 808 of the University Center. Dr. Wills may be contacted at 758-3638 or dw03@lehigh.edu.

Lehigh University Press

Lehigh University Press represents a clear expression of faculty and institutional commitment to the advancement of scholarship. Philip A. Metzger, Curator of Special Collections, Lehigh University Libraries, serves as director of the press, and members of the faculty of the four colleges serve on its editorial board.

The press is interested in all fine scholarship, but places special emphasis on traditional areas of strength at Lehigh: Science, Technology, and Society (STS) studies; and Eighteenth-Century studies. In linking the name of the university to a list of exemplary work by scholars across the nation, the press reinforces the value of excellence in the academic environment for faculty, graduate and undergraduate students alike, and helps to maintain intellectual contact with alumni.


For more information, contact Dr. Philip A. Metzger, Lehigh University Press, 30 Library Drive, Lehigh University, Bethlehem, PA 18015-3067.

Resources for Students

Lehigh's administrators firmly believe that the interrelationship between students' classroom and nonclassroom activities can be fostered to become an educational avenue through which students grow, accept responsibility, and gain maturity in ways that will contribute to productive and meaningful lives. Through various services, students are assisted in becoming informed decision makers. They are also encouraged to develop greater self-awareness and self-confidence in their ability to lead the lives they choose.

General counseling of individual students often begins in the residential setting. Staff members in the residence halls include five live-in professional residence life coordinators, and approximately eighty undergraduate residence hall counselors, known as Gryphons. All staff members are carefully selected, extensively trained, and are available to assist resident students who may have a variety of concerns.

Students are also encouraged to seek counsel and guidance from professionals in many areas of student life. The Office of the Dean of Students serves as a central agency to help students who have questions about academic and procedural matters, personal problems, legal problems, and other general concerns, both through its staff and through referral to other student affairs and academic offices. Through the programs and services provided by the Dean of Students office, students can become involved in community service, leadership skill development, multicultural opportunities, wellness education and a myriad of other activities designed to develop the well-rounded individual.

Students who need assistance with their physical well-being are referred to the university health center.

If a student has interests or concerns related to any personal or interpersonal issues, the office of University Counseling and Psychological Services offers a wide range of options, confidential and free of charge. Counseling Center staff, along with a group of student peer educators (Ta.L.Q.), interact with students around campus in classrooms, residence halls, and other settings. In addition, traditional services such as individual counseling, psychological evaluation, and crises intervention are provided by the licensed professionals in the center.

The university chaplain is available for the student with religious, moral, or personal concerns that are interfering with peace of mind and studies. A Roman Catholic chaplain also is in residence and available for counseling. A member of the faculty serves as advisor to Hillel Foundation members, who also may obtain spiritual advice from a local rabbi. The Office of Career Services offers assistance to students in identifying and developing career options that can be initiated at graduation.

The registrar assists students who have questions involving matters of transferred credits, graduation requirements, and allied topics.

The Office of Financial Aid consults with students who have financial concerns that are affecting their educational plans.

The Learning Center offers free individual tutoring in reading and study skills, mathematics, and writing.

Many members of the teaching faculty are also interested in students and student life. They serve as academic advisers, activity sponsors, group sponsors and advisers, and in friendly personal relationships with students.
The university offers health services to all students at the Health Center in Johnson Hall. During the fall and spring semesters, providers are available to see patients from 8:30 a.m. to 5:00 p.m. Monday to Friday. Providers include a nurse practitioner and two physicians daily. A registered nurse is present to see patients on weekends 11 a.m. to 4 p.m. with a provider on call. During breaks, hours are Monday to Friday 9:00 a.m. to 4:00 p.m.

The Health Center staff treats a variety of health problems, including illnesses and injuries. Gynecologic care is available by appointment. Allergy injections can be administered. Some minor surgery is performed at the Health Center. Many laboratory studies can be done at the Health Center; students are referred to local facilities for X-rays. Patients are referred to local medical and surgical specialists when indicated. More seriously ill students are sent to a general hospital.

Prior to arrival on campus, each new or transfer student must submit to the Health Center a record of physical examination, a completed health history form, and updated immunization record. Following enrollment, additional examinations are provided by the Health Center for students participating in intercollegiate athletic programs, and when required for graduate school or scholarship programs. The Health Center does not provide examinations for military, insurance or employment purposes.

There is no charge for most of the care provided to students. Some exceptions are as follows: referrals to physicians, hospitals, or other medical facilities outside the student Health Center, and medications not carried by the Health Center which require prescriptions. A low-cost university-sponsored insurance plan is available, which complements the services of the Health Center. Expenses covered include costs for services that are not available at the Health Center, such as X-rays, laboratory studies, consultant fees, and medications not stocked by the Center. Hospital expenses are also covered. Students are urged to check with their parents regarding existing insurance coverage and to consider purchasing the university-sponsored plan if they are not adequately covered. Please consult your insurance carrier or physician if your plan is of the managed care/preferred provider type.

A health service brochure is distributed to all entering freshmen and is available through the Health Center to all other students. This brochure describes in more detail the policies and programs of the health service. Or consult our web page at http://www.lehigh.edu/~inluhc/inluhc.html.

Counseling Service

The University Counseling Service (at 758-3880), with most services free of charge, is located on the fourth floor of Johnson Hall. The office is open from 8:00 - 5:00, Monday through Friday. Counselors are available for 24-hour emergency consultations via campus police (610-758-4200).

I. PHILOSOPHY & MISSION

The University Counseling Service (UCS) is dedicated to the belief that a person’s college years are a time of challenge, inquiry, experimentation, productivity and change. Services are designed to help students not only manage crises, but to thrive in meaningful ways . . . to grow in self-understanding in order to make more satisfying and better use of their personal and interpersonal resources. Individual contacts, group therapy, faculty and staff consultation, and numerous outreach activities are some of the primary means by which the mission is accomplished. UCS staff members are committed to providing assistance to all registered Lehigh students interested in personal, social, and academic growth and discovery, and to the larger campus community through consultation, teaching, research, and various other types of involvement.

II. DIRECT SERVICES

To accomplish its mission, and while upholding the established APA (American Psychological Association) ethical principles and code of conduct for psychologists, the UCS provides a variety of services to the Lehigh University community including:

* Crisis Intervention Services

The UCS provides assistance to individuals and groups in crisis. Psychologists provide 24-hour coverage via pager access (call campus police dispatcher at 758-4200) during the Fall and Spring semesters.

* Group and Individual Psychotherapy

UCS staff members provide group and individual counseling and psychotherapy services to both undergraduate and
graduate students. A short-term treatment model is used for individual work while much of the group work is of longer duration. Referrals for psychiatric consultation are made when requested and appropriate. All counseling and therapy services within the UCS are confidential.

* Outreach Programming
The UCS provides programming focused on the developmental needs of college students—designed to enhance the capacity of students to maximize their personal, social, and academic potential. These presentations occur in various settings, including living residences, classrooms, athletic sites, and meeting rooms across the university. Topics may include issues related to race, eating and body image, sexuality, drinking and other drug use, study styles, athletic performance, grieving, stress, and relationships. Much of this programming is done in partnership with T.a.L.q. (Talking about Life’s questions), a UCS sponsored student peer education group.

* Assessment and Evaluation
Upon request and when appropriate, UCS personnel administer and use personality and career advising instruments. They also utilize a wide variety of assessment tools when assisting groups and individual students.

* Consultation Services
Staff provide consultative services to the university community with the objective of helping students, faculty, and staff identify and resolve difficulties that may be exerting a negative effect on some individual, group, or system. This may include the use of referral resources within the university or in the local community.

* Training
One component of UCS work is to help persons such as residence life staff, peer counselors, university personnel, student leaders, and faculty more effectively advise, counsel, interact and communicate with others. A second component is to enhance the development of persons specifically interested in securing the identity and skills of a psychologist - these typically being graduate advanced practicum students, doctoral level interns, and professional staff.

* Advocacy
Staff of the UCS advocate for those students and groups who struggle for understanding and respect in a society sometimes blinded by traditional norms and expectations. Through dialogue, education, programming, consultation, and direct service, the staff is committed to being engaged with issues such as racism, sexism, and other practices that destroy self and group esteem.

The Center for Writing, Math and Study Skills: 110 Drown
Success at Lehigh depends, in part, on mastery of a number of advanced academic skills. Such skills are needed to write well, to understand advanced mathematical concepts, and to keep up with a great deal of critical reading.

Lehigh provides academic support to its students and staff through the maintenance of a network of writing, ESL (English as a Second Language), math and study skills consultants. The Center provides a variety of services such as (1) individual or small group tutoring for students enrolled in undergraduate math courses, (2) writing consultation for students and for the Lehigh community, (3) English language tutoring for ESL students, (4) study skills tutoring and advisement, (5) study assistance with learning disabled students, and (6) seminars and presentations to Lehigh student groups on effective study skills, time management, and several other topics. Tutoring and consultations are provided by graduate students and faculty; the service is free of charge.

The Center is located in room 110 of Drown Hall. Appointments can be scheduled by calling 758-3098. Both single-session and continuous weekly appointments are available. For more information, refer to the Center website at www.lehigh.edu/incent/index.html.

Career Services
One function of a college education is to foster the growth and development of the student in preparation for a meaningful and satisfying life after college. Since developing one’s career potential is an integral part of this process, Lehigh provides career planning and placement services for undergraduate and graduate students.

Career planning can best be described as an educational process through which students (1) identify and develop their abilities, aptitudes, and interests; (2) learn the relationship between their capabilities and interests, their university experiences, and professional opportunities outside the university; and (3) prepare for those opportunities.

Placement is the process of researching specific organizations that provide the types of work desired, interviewing for specific jobs through which career or professional interests can be satisfied, and then selecting from the options available the one that best meets students’ needs. This part of the process also requires students to develop skills in such areas as effective resume and cover letter writing, interviewing techniques, and individual job search strategies to enhance productive interactions with employers.

The goals of this integrated career planning and placement process are for Lehigh students to think of themselves as educated people with skills and abilities that have value to employers, to think in terms of functional responsibilities rather than merely linking their major subjects to jobs, to acquire and develop the skills necessary to become self-reliant and informed decision-makers, to prepare for a competitive job market, and to develop their potential of becoming self-reliant managers of their own careers.

The Office of Career Services is committed to the preparation and education of all Lehigh students during the transition from the academic environment to the work place. Career Services offers the following resources and services to help students prepare for professional opportunities after graduation:

**Career Counseling.** Students may meet with members of the staff to discuss their career options and goals, individual job-search strategies, effective interviewing, and related interests. Self-assessment tools are available to assist students in identifying interests, skills and values. Special requests for appointments outside regular office hours can also be arranged.

**Career Resources.** Among the resources available in the Career Library are books and articles on career planning, current information on career opportunities, occupational information, graduate school resources, job-search directories, a library of employer literature for approximately 600 companies, job listings for part-time, summer, internship, entry-level and experienced opportunities, and a database of alumni contacts who have volunteered to assist students with their job search strategies.

**Workshops and Special Programs.** The staff conducts a variety of seminars and presentations in collaboration with academic departments, professional societies, living groups, and other interested campus organizations. Career programs like the Career Fair and many others are offered throughout the year. Workshops on resume writing, interviewing techniques, networking, career portfolio, and job-search strategies are also offered. Often special programs are conducted each semester, including career panels, mini career classes, and informal gatherings focusing on a variety of fields.

**Experiential Education.** Experiential Education programs are
Distance Education:

The distance education program provides educational opportunities to adults at locations that are accessible to them and cost-effective for their employers. To remain competitive in a knowledge-based environment, companies need employees to continue their education. Lehigh has designed its distance education program in response to this need—providing convenient access to advanced education in the workplace. In partnership with Lehigh, students pursue graduate study at work, enabling them to earn a Master’s degree while maintaining full-time employment. Graduate degree programs available through the Lehigh Educational Satellite Network (LESN) are:

- Chemistry
- Chemical Engineering
- Molecular Biology
- Quality Engineering
- Polymer Science and Engineering
- and the MBA.

How it works: On-campus courses are broadcast by Ku-band digital satellite transmission and received "live" at corporate sites by industry students who actively participate in class by phone, fax, or interactive computer. Distance students have access to Lehigh's state-of-the-art computer and electronic library systems. In addition, distance students at all sites interact with each other as well as on-campus students through WWW-based chat rooms set up for individual courses. Admission and course requirements are the same for distance and on-campus students. Distance students are expected to view the courses live, interact with the instructors, and complete all assignments on time. As a result, when distance students complete a Lehigh credit program, they receive the same degree as on-campus students.

For more information, call the Office of Distance Education at (610) 758-5794 or check out our web page - http://www.lehigh.edu/~indic/index.html.

Summer Studies:

There has been a summer sessions program at Lehigh for nearly a century and, through the years, it has developed into a significant portion of the University's overall academic program. Lehigh now offers over 200 courses each summer. They range from travel programs in Europe, Asia, and the Rocky Mountains to on-campus courses that service Lehigh undergraduates and graduates, adult professionals in business and education, and students at other colleges who return to their Lehigh Valley region homes during the summer. At Lehigh, summer is a time for educational experimentation. Just in the past few years, new courses have been created in such areas as creative writing, ecosystem analysis, workplace diversity, and clinical counseling. Many of these are special summer offerings and not available during the regular academic year. For more information, call the Summer Studies Office at (610) 758-3966.

Continuing Education:

Lehigh University departments, research centers, and administrative agencies offer a varied selection of non-credit continuing education programs for adults. Reflecting Lehigh's traditional educational strengths, these offerings focus on professional development, organizational problem solving, and technical skills. These programs carry no regular academic credit, but participants can earn Continuing Education Units (CEUs). In awarding CEUs, Lehigh follows the guidelines developed by the National Council on the Continuing Education Unit.

Lehigh continuing education programs are often designed to meet specific needs. Contents, schedules, and timing are adapted to effectively serve the audiences for which they have been developed. Apart from public programs presented on the Lehigh campus, a number of programs are available for "in-house" presentation to organizations on a contract basis. For more information about these programs, contact the appropriate department or research center.

Challenge For Success Program

The Challenge for Success Program (CFS) is a comprehensive academic retention program that assists students of color in attaining their goals. The primary focus of the program is to provide support through academic and cultural programs. The philosophy of the program promotes that all students are born achievers, but all students need help actualizing their talents.

Retention is enhanced by a six-week summer scholars pre-freshman program, a peer mentoring program, counseling for social and academic adjustment, monitoring of academic progress and tutorial assistance. The Lehigh University Black and Latino Alumni Council (LUBLAC) also assists in the program's retention efforts.

This program is located in the University Center, Room 212.
Undergraduate Studies

Graduation Requirements
Students are expected to maintain regular progress toward the baccalaureate degree by carrying the “normal” course load—between 12 and 18 credit hours each semester. They may, however, wish to accelerate the pace toward graduation by using advanced placement credits, summer session study, course overloads during the regular semesters, and receiving credit for courses through examination.

Students in good academic standing earn their degrees by meeting the requirements of their specific degree curriculum as well as general university requirements. Students should confer with their advisers on matters related to curriculum.

Students are expected to satisfy the credit-hour requirements of their chosen curriculum. Basic military science or aerospace studies credit hours are in addition to the credit hours specified in the curricula. A maximum of six credit hours of advanced military science and aerospace studies courses may be applied toward the baccalaureate degree.

Undergraduate Residency Requirement
To be eligible to receive a Lehigh baccalaureate degree, the candidate must have completed either a minimum of 90 credit hours in residence, or all of the last 30 credit hours at the University or in residency programs.

Five-Year, Two-Bachelor-Degree Programs
The university’s five-year, two-degree programs enable a student to receive two bachelor degrees upon completion of five years of study.

The civil engineering and geological sciences program that affords two bachelor degrees, and the electrical engineering and engineering physics two-degree program are examples of programs in the College of Engineering and Applied Science.

Some five-year, two-degree programs appear in the description of courses under Arts-Engineering and Five-Year Programs in Section V. It is possible to arrange for a dual bachelor degree program even after studying at Lehigh for some time. Engineering students, for example, who decide at any stage of study that they wish to meet the requirements for both the bachelor of arts and bachelor of science degree may complete the combined requirements in five years if the decision is made before the third year.

Second degree candidates—A student entering Lehigh to obtain a second bachelor’s degree, or those Lehigh students who wish to declare a second major in another college, or both a B.A. and a B.S. degree within the College of Arts and Sciences must have a minimum of 30 additional credit hours beyond the first degree credit-hour requirements in order to qualify for the second degree. All of the 30 additional credit hours must be taken at Lehigh or in Lehigh residency programs. All special second degree programs must be approved by the dean of the college in which the degree is to be offered and the Standing of Students Committee.

Advisement
Every undergraduate is assigned a faculty adviser. Until the major is declared, assistance is also available through the dean’s office of the college in which the student is enrolled. When the major has been chosen, a faculty member from the major department will act as the academic adviser.

Guide to Academic Rules and Regulations

Eligibility for Degree
In order to be graduated, a candidate for a baccalaureate degree must achieve a minimum cumulative average of 2.00.

To be eligible for a degree, a student must not only have completed all of the scholastic requirements for the degree, but also must have paid all university fees, and in addition all bills for the rental of rooms in the residence halls or in other university housing facilities. Payment also must have been made for damage to university property or equipment, or for any other indebtedness for scholarship loans or for loans from trust funds administered by the university.

Responsibility for meeting academic requirements. Each student is responsible for his or her progress toward meeting specific requirements for graduation. Academic advisers and department chairs are available to assist the student. It is strongly recommended that the student specifically consult with his or her adviser prior to the senior year to ascertain eligibility for the degree for which he or she desires to qualify and to determine that all program and hours requirements are met.

The registrar's office will provide, at the student’s request, a printout of a degree audit noting all program deficiencies. All students are required to go through this process before registering for their senior year.

Final date for completion of requirements. For graduation, all requirements, scholastic and financial, must have been satisfied prior to the date stated in the university calendar.

Application for Degree
Candidates for graduation on University Day in May or June must file with the registrar on or before March 1 a written notice of candidacy for the degree; candidates for graduation in January file a notice of candidacy on or before November 1.
Failure to file such notice by such dates mentioned debars the candidate from receiving the degree at the ensuing graduation exercises. If a petition for late filing is granted, a fee is assessed.

**Graduating Thesis**
The original of the undergraduate thesis, when required, is accompanied by drawings and diagrams whenever the subject needs such illustration. The original is kept by the university, as a part of the student's record, for future reference; but copies may be retained by students and may be published, provided permission has first been obtained from the faculty.

**Undergraduate Credit and Grades**
A "semester hour," used interchangeably with "credit hour," is a course unit normally involving three to four hours of student effort per week during one semester. This includes both in-class contact hours and out-of-class activities. The major parameters influencing the in-class/out-of-class division include the mode of instruction and the level of the course.

**Latest date for registration.** No registration is accepted later than the tenth day of instruction in any semester, or fifth day of a summer session.

Definitions of grades. Course grades are A, A-, B+, B, B-, C+, C, C-, D+, D, D-, P, F, N, and X. The meaning of each grade is as follows: A, A-, excellent; B+, B, and B-, good; C+, C, and C-, marginal; D+, D, and D-, passing, but performance is not adequate to take any subsequent course which has this course as a prerequisite. The student must petition to waive a prerequisite. Upon presentation of evidence of substantially equivalent preparation and with the approval of the chair of the major department, the prerequisite will be waived. P, pass-fail grading with a grade equivalent to D- or higher; F, failing; N, incomplete; X, absent from the final examination; XN, absent from the final examination and incomplete.

Other symbols used for courses on student records are: Cr, credit allowed; W, withdrawn; WP, withdrawn with permission and with passing performance at the time of withdrawal; WF, withdrawn beyond the deadline and/or with failing performance.

Grades in the range of A through D- and Cr may be credited toward baccalaureate degrees within the limits of program requirements. Grades of F, N, X, XN, W, WF, and WP cannot be credited toward the degree. Grades of W and WP do not count as hours attempted.

Courses in which grades of D+, D, D-, F, W, WF, N, X, or XN are recorded do not meet prerequisite requirements.

The grade N (grade) may be used to indicate that one or more course requirements (e.g., course report) have not been completed. It is the obligation of the student to explain to the satisfaction of the instructor that there are extenuating circumstances (e.g., illness or emergency) that justify the use of the N grade. If the instructor feels the N grade is justified, he or she assigns a grade of N supplemented by a parenthetical letter grade, (e.g., N(C)). In such cases, the instructor calculates the parenthetical grade by assigning an F (or zero score) for any incomplete work unless he or she has informed the class in advance that he or she would use N(C), the student dropping all courses for which he or she is registered is considered to be withdrawing from the university and the policy is noted below. A student who drops a course after the tenth day of instruction and before the end of the eleventh week of instruction will have a grade of "W" assigned to the course. A student who drops a course after the eleventh week of instruction and before the end of classes receives a "WF" or "W" at the discretion of the instructor. A "WF" is considered to be a failing grade. An Add/Drop form signed by the student's advisor must be submitted to the registrar's office, before the deadlines noted above, to be official.

In no case shall the grade N be used to report absence from a final examination when all other course requirements have been met.

N grades do not count as hours attempted and are not used in computations of cumulative averages.

The grade X (grade) is used to indicate absence from the final examination when all other course requirements have been met. The grade in parentheses is determined by including in the grade calculation an F (or zero score) for the missing final exam. The X grade may be removed by a make-up examination if the absence was for good cause (e.g., illness or other emergency). To be eligible for the make-up exam, the student must file a petition and the petition must be approved by the Committee on the Standing of Students. If the student fails to petition, or if the petition is not granted, or if the student fails to appear for the scheduled make-up examination, then the X grade will be converted into the parenthetical grade after the first scheduled make-up examination following the receipt of the X grade. If the petition is granted and the final examination is taken, the X grade will be changed by the instructor using the make-up examination procedures and the parenthetical grade will be dropped from the transcript.

Where valid reasons exist for not taking the make-up examination at the scheduled time, the student may petition for a later examination with a fee. The notation of NR (not reported) is temporarily placed in a student record when due to circumstances, no grade was reported by the instructor by the established deadline.

The grade XN (grade) is used to indicate both absence from the final examination and incomplete of one or more course requirements. The instructor calculates the parenthetical grade using an F (or zero score) for the final examination and either an F (or zero score) or the substitute method of calculation as described above for the incomplete work.

The XN grade may be removed by the procedures presented in the previous paragraph for removing the X grade. If this results in an N grade because the course work is still incomplete, the provisions Incomplete (N grade) above shall apply, except that in no case shall the deadline for completion of the work be later than the last day of classes in the first full semester in residence (except summer) following receipt of the XN grade.

X and XN grades do not count as hours attempted and are not used in computations of cumulative averages.

Withdrawal From A Course. A student dropping a course within the first ten days of the semester (five days for summer sessions) will have no record of the course on the transcript. A student dropping all courses for which he or she is registered is considered to be withdrawing from the university and the policy is noted below. A student who drops a course after the tenth day of instruction and before the end of the eleventh week of instruction will have a grade of "W" assigned to the course. A student who drops a course after the eleventh week of instruction and before the end of classes receives a "WF" or "W" at the discretion of the instructor. A "WF" is considered to be a failing grade. An Add/Drop form signed by the student's advisor must be submitted to the registrar's office, before the deadlines noted above, to be official.
University Withdrawal. A student withdrawing from the university (dropping all courses during a given term) must submit the withdrawal form to the dean of students office. Withdrawal after registration day and during the first 11 weeks of instruction will be noted on the academic transcript by assigning a grade of “W” to all courses. A withdrawal after the eleventh week of instruction and before the end of classes will have the grade of “WP” or “WP,” assigned for each course at the discretion of the instructor. The date of the withdrawal will be noted on the academic transcript for a withdrawal at any time during the term.

A student who reduces his or her course load below the minimum required for standing as a full-time student, but does not withdraw from the university, becomes a part-time student for the rest of that semester. Some areas affected by part-time status are financial aid, athletic eligibility, veterans affairs, selective service, immigration status, insurance and loan deferment.

Official reports of grades are issued to advisers and students by the registrar as soon as possible following the deadline for reporting of grades. Instructors may develop their own policies for release of unofficial reports of academic progress to individual students, or to their advisers, deans, or financial aid officers, on a need-to-know basis, including early release of unofficial final course grades. Any such policies must respect the rights of students to privacy.

A report of grades is sent to each student’s home at the end of every semester.

Repeating of courses. If a course in which a “C-” or lower grade was received is repeated, the final grade received upon repetition of the course is counted in the cumulative average. The original grade and credit hours received will be dropped from the cumulative average. Courses assigned a grade of “C” or better may not be repeated. However, a student who fails a repeated course after receiving a passing grade the first time will have the original grade deleted from his or her average, but will retain credit for the course toward graduation.

A grade of C or lower that was originally received in a course may not be changed by repeating the course under the pass-fail option.

For deletion of a grade from the cumulative average after repeating a course, a student must (a) file the deletion form with the registrar’s Office; and (b) repeat the identical course with a final grade at Lehigh.

Pass-Fail Systems for Undergraduates

Student Option System. The pass-fail grading option is intended to encourage students to take challenging courses outside the major field that otherwise might be avoided for fear of lowering grade-point averages. Students are not permitted to take courses numbered below 100 and over 400 using the optional pass/fail grading system and should avoid wasting this option on unsuitable courses, such as courses having no college-level prerequisite or corequisite. The restrictions on the use of the system are listed below.

A student may register for no more than one course pass-fail numbered above 100 and below 400 in any one semester. He or she may take a maximum of six courses pass-fail per undergraduate career if the student is on a four-year program, or a maximum of eight courses per undergraduate career with a five-year, two-degree program. If a student changes a course after the first ten days of instruction from pass-fail grading to regular grading, as provided below, that course shall still count toward the maximum number of courses taken pass-fail during the student’s undergraduate career.

Each college faculty shall decide under what conditions and which courses or categories of courses throughout the university may be taken for pass-fail credit by students registered in that college, except for courses designated specifically for pass-fail grading. Each college shall keep the educational policy committee advised of changes in its rules.

A student designates the course(s) to be taken pass-fail normally at preregistration but not later than the fifteenth day of instruction in a regular semester or the fifth day of instruction in any summer session. Prior to this deadline, the student may transfer from pass-fail to regular grading, or vice-versa, without penalty. The courses designated for pass-fail grading by the student require the written acknowledgment of the academic adviser.

Since the instructor giving the course is not officially notified which students are taking the course pass-fail, a regular letter grade is reported to the Registrar for the pass-fail students. The Registrar then records “P” for reported letter grades from A through D-, and “F” for a reported letter grade of F.

Under this system, the student surrenders his or her equity to letter grades of A through D-, except as specified below. A grade of P applies to the student’s graduation requirements but is not used in the computation of the cumulative average; whereas an F grade is included in the cumulative grade point average.

If a student changes his or her program such that a course previously taken for pass-fail grading is not allowed for pass-fail grading in the new program, the student must submit a petition to the Committee on the Standing of Students requesting acceptance by the new program of the pass-fail grading for that course, or substitution of the original letter grade submitted by the instructor for the pass-fail grade, or the substitution of another course for the course taken pass-fail. The recommendation of the adviser must accompany the petition.

Courses at the 400-level are excluded from pass-fail grading.

Course Auditing

A student who is in good academic standing and has not failed any courses in the previous term may be admitted as an auditor in not more than one course, which shall be outside the curriculum requirements. Application for such admission is by petition approved by the departmental chair and the chair of the department concerned. In no case shall a student who has attended a course as an auditor be given an anticipatory examination for credit or register for the same course in the future. A student completing a course in this manner will have the course and the notation AU indicated on the permanent record. A student rostered on an audit basis may be withdrawn from the course with a grade of W for poor attendance.

Review-Consultation-Study Period

The Review-Consultation-Study (RCS) period is intended to provide a few days for informal academic work between the end of the formal instruction period and the beginning of the final examinations.

It is expected that students will use this period to consolidate their command of the material in their courses. Faculty members make themselves available to their students at announced times during this period.

No quiz or exam may be given during the last five class days before final examination period begins.

Scholastic Averages and Probation

Scholastic requirements for undergraduate students are expressed in terms of the cumulative grade point average (GPA)—the weighted average of all grades received in residence or at institutions specifically approved for grade transfer. The cumulative GPA is computed at the end of each semester and the second summer session. Following are the cumulative GPA requirements for good standing:

- freshmen 1st semester 0 to 6 credits earned
- 1.60
- 1.70
- 1.80
- 2.00

Students who do not meet the above requirements will be placed on scholastic probation. Students who, regardless of their
cumulative average, have failed more than eight hours of course work in any semester are also placed on scholastic probation.

While there is no specific credit hour requirement for good standing, certain categories of students (e.g., those on financial aid and those playing intercollegiate athletics) will be expected to maintain whatever hours are required for eligibility.

Removal from probation. Students are removed from probation at such time as they meet the standards stipulated in this section. A student who makes a 2.2 GPA or better in the probationary semester but fails to meet the standards stipulated is continued on probation for another semester. A student who makes less than a 2.2 GPA in the probationary semester and fails to meet the standards stipulated above, is dropped for poor scholarship.

If a student goes on scholastic probation for a second (although not necessarily consecutive term,) a review by the Committee on the Standing of Students will determine whether the student will continue on scholastic probation or be dropped for poor scholarship.

Graduation Honors

Degrees with honors are awarded by vote of the university faculty to those students who have attained an average of not less than 3.25 in a minimum of 90 credit hours in residence at Lehigh University or in programs approved by the faculty to have grades and credit accepted toward the undergraduate degree.

Degrees with high honors are awarded by vote of the university faculty to those students who have attained an average of not less than 3.50 in a minimum of 90 credit hours in residence at Lehigh University or in programs approved by the faculty to have grades and credit accepted toward the undergraduate degree.

Degrees with highest honors are awarded by vote of the university faculty to those students who have attained an average of not less than 3.75 in a minimum of 90 credit hours in residence at Lehigh University or in programs approved by the faculty to have grades and credit accepted toward the undergraduate degree.

For the purposes of graduation honors calculations, courses taken more than once at Lehigh will only have the most recent grade used in the calculation. Courses taken under the cross-registration policy of the LVAIC, the Washington Semester and the Urban Studies semester program will be used.

Students who spend part of their career at another institution, or are transfer admits to degree programs and have fewer than ninety hours of in residence courses, may qualify for graduation honors under the following conditions:

The student must have at least sixty credit hours of regularly graded (not pass/fail) courses that meet the residency requirement. The graduation honors category is determined by the lower of the two averages computed as follows: (1) the average of grades received at Lehigh; (2) the average of all grades received at Lehigh and grades for courses taken elsewhere for a regular grade and that are appropriate to be considered for transfer to Lehigh, or in provisionally approved study abroad programs.

Department Honors

Many departments offer honors work adapted to its curriculum for students who wish to demonstrate unusual academic ability and interest in exploring a chosen field through independent study and research. The precise nature of the program for each student is determined by the academic major department, but may include: unscheduled work or independent study, participation in graduate (400-level) courses, and an honors thesis or project.

Qualified candidates should inform their academic advisers by the end of the junior year of their intention to work for departmental honors. The adviser will give the college and the registrar names of seniors working for departmental honors in particular majors. Names of those students attaining departmental honors are published in the commencement program.

Undergraduates in the College of Arts and Sciences may apply for acceptance into the College Scholar Program, which offers unique opportunities for those qualified to develop their critical faculties and intellectual interests.

Honor Societies

There are at least 18 honor and course societies. The three best-known are:

Phi Beta Kappa. The oldest honor society in the United States invites its membership those undergraduates from each of Lehigh's three undergraduate colleges who meet the following desired profile:

· A minimum cumulative GPA of 3.5
· A minimum of six hours each of natural sciences (including a lab); special sciences; and humanities (especially reading/critique of literature beyond freshmen English)
· Calculus or advanced mathematics that requires calculus as a prereqisite
· Foreign language roughly equivalent to second year college level
· No academic violations sufficient to warrant suspension

While satisfaction of this profile does not guarantee election, it ensures being considered by the council of the Beta chapter of Pennsylvania and the Alpha Gamma chapter of the United States

Beta Gamma Sigma. Election to membership in Beta Gamma Sigma is the highest scholastic honor that a student in business administration can achieve. Beta Gamma Sigma is the only national honorary scholarship society in the field of business administration recognized by the American Assembly of Collegiate Schools of Business.

Tao Beta Pi. Tau Beta Pi recognizes high achievement in all engineering curricula. The national Tau Beta Pi was founded at Lehigh in 1885. A bronze marker in front of Williams Hall commemorates this event.

Among course societies are the following: Alpha Pi Mu, for those in industrial engineering; Beta Alpha Psi, accounting; Chi Epsilon, civil engineering; Eta Kappa Nu, electrical engineering; Lambda Mu Sigma, marketing; Omicron Delta Epsilon, economics; Omicron Delta Kappa, leadership; Order of the Omega, leadership in Greek activities; Phi Alpha Theta, history; Phi Beta Delta, international; Phi Eta Sigma, freshman scholastic excellence; Pi Tau Sigma, mechanical engineering; Psi Chi, psychology; Sigma Tau Delta, English; and Sigma Xi, research.

College of Arts and Sciences

Bob Carson, dean
Gary G. DeLeo, associate dean; Alexander M. Doty, associate dean

The College of Arts and Sciences offers several curricular options:

· A four-year curriculum in arts and sciences, leading to the degree of bachelor of arts; or bachelor of science in designated fields; and
· A five-year curriculum in arts-engineering leading to a bachelor's degree from the College of Arts and Sciences and bachelor of science degree in a specific field from the College of Engineering and Applied Science.
· Double degree programs within the college and in conjunction with the other two undergraduate colleges are possible. Specific requirements for many of the degree programs described in this section may be found in Section V.
Major Programs in the College

The college offers the following major degree programs:

Bachelor of Arts Degree

Humanities: architecture; art; Asian studies; classics—classics and classical civilization—English; modern languages and literature—French, German and Spanish; music; philosophy; religion studies; Russian studies; theatre.

Social Sciences: Africana studies; American studies; anthropology; cognitive science; economics; history; international careers; international relations; journalism; journalism/science writing; political science; psychology; science, technology and society; social relations; sociology/social psychology; and urban studies.

Mathematics and Natural Science: behavioral neuroscience; biology; chemistry; computer science; earth and environmental sciences; mathematics; molecular biology; natural science; physics; preclinical science; premedical science; and preoptometry science.

Bachelor of Science Degree

Behavioral neuroscience; biochemistry; biology; chemistry; computer science; earth and environmental sciences; mathematics; molecular biology; physics; statistics.

Major Field of Concentration

By the end of the sophomore year, each student in the curriculum of arts and sciences usually selects one sequence of studies as a major field of concentration. A major consists of at least 15 hours of advanced work in the field chosen. Including preliminary college work, the minimum number of hours constituting a major is 30.

The major field of concentration is designed to enable a student to master an area of knowledge so far as that is possible during the undergraduate years. Each field prescribes certain courses, and a student must achieve a minimum 2.0 average in major courses.

Standard major sequences. The student may choose one of the standard major sequences. When a student elects one of the standard majors, a faculty member from the department or program offering the major becomes a student's major adviser and assists the student in constructing a program of study. The final responsibility for selecting major and nonmajor requirements, however, rests with the student.

Special interdisciplinary majors. In addition to the standard major programs, specially structured interdisciplinary major sequences between majors are possible. For example, a student interested in a professional school of urban or regional planning might wish to structure a special major consisting primarily of courses in political science and economics, or in economics and social relations.

Any student may, with the aid of faculty members chosen from the disciplines involved, work out an interdisciplinary major program to include not less than thirty hours of related course work, of which at least 15 hours shall consist of advanced courses. The program must be approved by the major advisers and the dean of the college.

Multiple majors/Double degrees. Students who wish to fulfill the requirements for more than one major sequence may initiate this process by having separate major programs constructed by the corresponding advisors. The college distinguishes between standard major sequences and interdisciplinary major programs leading to multiple majors and multiple degrees. Multiple majors may be constructed from two or more B.A. degree programs, with double majors often completed in four years. Double-degree candidates have chosen to pursue a second degree in another college, or receive two B.S. degrees of a B.A. and a B.S. degree from within this college. These students must petition the standing of students committee, satisfy both sets of major and distribution requirements, and receive a minimum of 30 additional credit hours beyond those required for the first degree. All of the 30 additional credit hours must be taken at Lehigh or in Lehigh residency programs.

Because successful completion of only one major program is required for a baccalaureate degree, a student with more than one program is asked to designate one as the primary major for administrative purposes but is expected to maintain normal progress in fulfilling the requirements in both.

Junior-Year Writing Certification

The faculty of the College of Arts and Sciences is committed to the concept that writing is a valuable tool for learning and views the ability to write well as an essential professional skill. Students are encouraged to take courses that require writing throughout their years in the college.

Each student in the college must complete at least one "writing-intensive" course and receive writing certification from the instructor. Students normally take this course during the junior year. Students must follow the guidelines for this requirement set up by their major departments. Some departments specify that the "writing-intensive" course must be in the major field; some departments require "writing-intensive" courses in specified disciplines other than the major; and other departments allow their majors to choose freely from "writing-intensive" courses across the college. Courses that satisfy the junior-year-writing requirement may also satisfy major or distribution requirements.

Bachelor of Arts and Bachelor of Science Degrees

The curriculum in arts and science emphasizes a liberal education. It asks the student, in collaboration with the adviser, to select courses to satisfy three general categories, namely, distribution to insure breadth of education, a major field of concentration to provide depth, and free electives to provide breadth and depth to meet the student's needs.

A student electing to work for the bachelor of science (B.S.) degree may have a strong preprofessional orientation and will take more courses in the major field of concentration than will another in the bachelor of arts (B.A.) program. In all other respects the student in a bachelor of science curriculum meets the same requirements as the student in the bachelor of arts program.

The bachelor of arts and bachelor of science degrees require the completion of a minimum of 121 credit hours of collegiate work, apportioned to cover distribution and concentration requirements. A cumulative average of 2.0 or better in courses required in the student's major program and the completion of all general requirements apply to all candidates for baccalaureate degrees. A maximum of six credit hours of advanced military science courses may be applied toward the degree.

Distribution Requirements for the B.A. and the B.S.

Distribution requirements are intended to ensure a breadth of learning without imposing undue restrictions on a student's course of study. Each distribution requirement may be fulfilled with a variety of courses, which can be chosen to complement the student's interests. No course applied to distribution may be taken pass-fail.

A College Seminar or other designated "First-Year Class" (FYC) must be taken in the freshman year. This unique course allows students to study a subject of personal academic interest with an established faculty member who is an expert in the field. Seminars are usually limited to 20 students and encourage close interpersonal relationships with faculty and peers, heightened intellectual engagement, and freedom to explore and discuss ideas as they arise.

A. Arts 1, Choices and Decisions (first semester at Lehigh) 1 hour
B. College Seminar/First-Year Class (one course during the first year) 1-4 hours
Students and advisors should monitor closely the progress toward completion of requirements D through G. Courses taken within a major department to satisfy a major may be used to satisfy distribution requirements in only one distribution area; i.e., natural science, social science, or arts and humanities - no mixtures. Also, First-Year Classes contribute credit(s) toward one of the distribution areas below.

C. English Composition
   (two courses during the first year)

   Students and advisors should monitor closely the progress toward completion of requirements D through G. Courses taken within a major department to satisfy a major may be used to satisfy distribution requirements in only one distribution area; i.e., natural science, social science, or arts and humanities - no mixtures. Also, First-Year Classes contribute credit(s) toward one of the distribution areas below.

D. Mathematical Sciences
   Chosen from mathematics or designated courses from
   philosophy or computer science

E. Natural Sciences
   Chosen from those designated in: astronomy,
   biological anthropology, biosciences, chemistry, earth
   and environmental sciences, physics, and neuroscience.
   At least one science course must also include the
   associated laboratory.

F. Social Sciences
   Chosen from those designated in:
   anthropology, classics, economics, political science,
   history, international relations, journalism,
   psychology, social psychology, social relations,
   sociology, STS, and urban studies.

G. Arts and Humanities
   Chosen from those designated in: architecture,
   art, classics, history, modern languages and literature,
   English, music, philosophy, religion studies, and
   theatre.

Total required for graduation: 121 hours

A student’s program, including the choice of distribution
requirements, is not official until approved by the adviser.

Foreign Language Study
Students who are planning on graduate study toward a doctoral
degree are reminded that most graduate schools require
doctoral candidates to demonstrate a reading knowledge of one
or two foreign languages. Ability to use foreign languages is
beneficial in many careers, such as law, journalism, commerce,
industry, and government.

Centers and Institutes
The college participates in research and scholarship in a number
of centers and institutes, where graduate and undergraduate
students work closely with faculty members. These include:
Building and Architectural Technology Institute, Center for
Innovation Management Studies, Center for Social Research,
Emulsion Polymers Institute, Energy Research Center, Institute
for Bioengineering and Mathematical Biology, Lawrence Henry
Gipson Institute for Eighteenth-Century Studies, Materials
Research Center, Philip and Muriel Berman Center for Jewish
Studies, Center for Polymer Science & Engineering; Sherman
Fairchild Center for Solid-State Studies, Technology Studies
Resource Center, Zettlemoyer Center for Surface Studies.

Minor Programs in the College
Certain departments, divisions, and programs in the College of
Arts and Sciences afford an opportunity to minor in an
additional field of concentration other than the major field.
A minor consists of at least 15 credit hours; the specific content
is determined by the department, division, or program
concerned. A minor is optional and, if successfully completed,
will be shown on the university transcript in the same manner as
the major field of concentration. A 2.0 minimum grade-point
average is required for courses in the minor. Because of this
requirement, no course in the minor program may be taken
with Pass/Fail grading. No more than one course may be
double-counted toward a major and a minor.

It is the responsibility of students desiring a minor to initiate it
no later than the beginning of the junior year by filing a minor
program with the department, division, or program where it is
offered. The student’s minor advisor maintains appropriate
records.

Minors in the College of Arts and Sciences departments and
programs are available for degree candidates in other colleges
within the university, with approval of their college adviser.

The following are established minors in the College of Arts
and Sciences. Program descriptions may be found in the
alphabetical listing of Section V. Some minor-program
descriptions are collected within departmental descriptions, or
located elsewhere, as indicated by parentheses.

Actuarial Science (Mathematics)
African Studies
American Literature (English)
Anthropology (Sociology and Anthropology)
Architecture (Art and Architecture)
Art (Art and Architecture)
Art / Architecture History (Art and Architecture)
Asian Studies
Astronomy (also see Mathematics)
Biology (Biological Sciences)
British Literature (English)
Chemistry
Chinese (Modern Languages and Literature)
Classical Civilization (Classical Studies)
Classics (Classical Studies)
Cognitive Science
Communication (Journalism and Communication)
Computer Science (Electrical Engineering and Computer Science)
Earth and Environmental Sciences
Economics
Education (Education Minor, this section)
English
Environment and Society
French (Modern Languages and Literature)
German (Modern Languages and Literature)
Graphic Communication (Art and Architecture)
Health and Human Development (Health Professions Programs,
this section)
History
International Relations
Jewish Studies
Journalism (Journalism and Communication)
Latin American Studies
Mathematics, Applied (Mathematics)
Mathematics, Pure (Mathematics)
Military Science
Molecular Biology (Biological Sciences)
Museum Studies (Art and Architecture)
Music
Philosophy
Physics
Political Science
Probability and Statistics (Mathematics)
Psychology
Public Administration (Political Science)
Public Relations (Journalism and Communication)
Religion Studies
Russian (Modern Languages and Literature)
Russian Studies
Science, Technology and Society
Science Writing (Journalism and Communication)
Social Relations (Sociology and Anthropology)
Sociology (Sociology and Anthropology)
Social Psychology (Sociology and Anthropology)
The Roy Eckardt College Scholar Program is intended for students who show outstanding academic promise or unusual creativity and those whose interests transcend traditional programs. It is a highly selective program, restricted to a small number of especially qualified students, some of whom are enrolled at the time of admission to the university and the rest in the following two years. Applications from entering freshmen are evaluated by the admissions office and the College Scholar Advisory Council based on their written statements of educational goals, high school records, college board test scores, and teachers' recommendations. Applications from freshmen and sophomores are evaluated by the advisory council on the basis of their academic records and written statements of educational goals, and recommendations from at least two faculty members. The program allows students to devise individualized courses of study and to engage in scholarly work of an advanced nature. Participants are obliged to obtain 121 credits, including Arts 1 and the junior writing requirement, take at least one college seminar and, if they are enrolled in over-all program, have the director with the advice of the director of the major field. The major assignments of the program are sections V. Students present accounts of their projects at the annual college scholar graduation dinner. The award of the College Scholar graduation honors is subject to the recommendation of the program director (Prof. Ian Duffy, 340 Maginnes Hall) and the chair in the major field.

In addition to the academic privileges of the program, college scholars are offered a variety of extracurricular opportunities. These include invitations to meet visiting speakers, informal meetings with faculty members, dinners, lectures, plays, musical events, and other cultural activities in the Lehigh Valley and nearby cities. For a listing of courses and advisory council members, see Roy Eckardt College Scholar Program entry, section V.

College Seminar/First-Year Class (FYC) Program

During the fall or spring semester of the freshman year, every freshman student in the College of Arts and Sciences is required to enroll in a “First-Year Class” (FYC) taught by a member of the faculty. With ten to 20 students per class, these college seminars and special classes provide an intimate and supportive environment that facilitates the transition to university life. Students begin to develop many of the skills that serve as a framework for their future scholarly work—how to read closely, think critically, write clearly, learn cooperatively, speak persuasively, and solve problems creatively.

First-Year Classes, including college seminars, are an excellent way to explore a subject that may be new, or to enter more deeply into an area of previous interest. Many of the topics are non-traditional or interdisciplinary subjects of special interest to the professor.

Whatever the topic, FYCs involve considerable effort on the part of students. Some classes emphasize reading assignments, papers, and oral presentations; others include tests, laboratory work, or fieldwork. Each FYC fulfills a college distribution requirement.

Pre-Law Programs

The university has a strong pre-law tradition. In keeping with the policy of the Association of American Law Schools, the university does not have a prescribed pre-law program.

Lehigh students have been successful in attaining entrance into law schools from diverse curricula in all three of the undergraduate colleges. Law-related courses, some of which rely on the case method, are provided by both the College of Arts and Sciences and the College of Business and Economics. These courses are open to all students, including those in the College of Engineering and Applied Science. Illustrative courses in arts and sciences include constitutional law, civil rights, administrative law, media ethics and law, and American constitutional and legal history. Correspondingly, there are courses such as Introduction to Law and Legal Environment of Business in the College of Business and Economics. That college also offers basic accounting courses that are often recommended as part of an undergraduate's pre-law preparation. Students interested in pursuing a postgraduate legal education should contact one or more of the professors in these courses.

In addition to formal academic instruction, Lehigh provides other opportunities for learning about law and careers in law. The annual Tresolini Lecture series brings nationally recognized speakers to campus for extended interactions with faculty and students. Tresolini lecturers have included present and past U.S. and state Supreme Court justices and renowned legal scholars and practitioners. Lehigh also provides opportunities for gaining academic credit in several off-campus programs which provide practical experience in law and public affairs.

Counseling is available to prospective pre-law students on a continuous basis from freshman orientation through the law school application process in the senior year. An advisory committee, composed of faculty members and the pre-professional advisor in career services, coordinates these pre-law counseling services. Students are urged to consult members of this committee as early as possible in their academic careers.

Health Professions Programs

Schools of medicine, dentistry, optometry, podiatry, and veterinary medicine stress the importance of a strong liberal arts education as well as prescribed studies in the sciences. Although most pre-health students will choose a major in a pure or applied science, as long as candidates have the essential courses in biology, chemistry, physics, and mathematics, they may major in any of the three undergraduate colleges.

A health professions advisory committee, which includes a pre-professional advisor and faculty members from biology, chemistry, and physics, provides career and academic counseling and works closely with students from freshman orientation through the entire process of applying to professional schools. Students are urged to consult with the pre-professional advisor as early as possible in their academic career. Students interested in other allied health fields may also obtain information to aid them in planning their courses with their academic advisors.

Combined-Degree Program in Medicine

In cooperation with MCP Hahnemann School of Medicine the university offers an accelerated program that enables selected students to earn both the bachelor of arts degree in premedical science and the M.D. degree after a minimum of six or seven years of study at the two institutions. The program was initiated in 1974, and approximately ten students are admitted each year.

The program includes two or three academic years at Lehigh, during which time a minimum of 91 credit hours are earned toward the 121 credits required for the baccalaureate degree. The next four years are spent in the regular program of medical education in Philadelphia. After successfully completing the first two years at the medical school, students will have acquired the necessary additional credit hours for the baccalaureate degree.

During the pre-professional years at Lehigh, students are expected to make satisfactory progress in academic areas as well...
as in the more subtle task of personal growth in those attributes ultimately needed as a physician. MCP Hahnemann School of Medicine receives student grades and monitors student progress through feedback from Lehigh staff. Students are expected to maintain an overall GPA of 3.45 or better (A=4.0) and no grade(s) less than a “C”. Credentials again will be processed through the medical school’s Admissions Committee prior to extending a final definitive acceptance. This program also requires that students take the Medical College Admissions Test. The results will be evaluated by the committee prior to final acceptances. It is expected that the three numbered scores be “9” or better on the 1-15 scale.

The medical college reserves the right to withdraw an offer of acceptance if academic or personal concerns cause the college to question a student’s academic or personal maturation.

Application for admission to the program is made through the Lehigh Office of Admissions. Criteria for admission include SAT scores (minimum combined score of 1360 recentered scale), scholastic achievement, maturity, and motivation for medicine. SAT II scores are not required but are recommended (i.e. mathematics, English composition, and chemistry).

Completed applications are reviewed by the Office of Admissions, and a pool of students are chosen for interview by the MCP Hahnemann School of Medicine. Interviews are not required at Lehigh, but students are encouraged to make arrangements to come to campus to have an interview and to become better acquainted with Lehigh and the special features of this program. Application deadline is December 1. Course work for a two-year format follows:

### Year 1, fall
- Arts 1 (1)
- Engl 1 (3)
- Chm 21, 22 (5)
- Math 21 or 51 (4)
- Humanities (3)

### Summer 1:
- Chm 51, 53 (4)
- Chm 52, 56 (4)
- Elective (free) (3)
- Elective (free) (3)

### Year 2, fall
- Phy 11, 12 (5)
- BioS 31, 32 (4)
- Math 23 or Math elective (3-4)
- Humanities (3)
- Elective (free) (3)

### Summer 2:
- Humanities (3)
- Social Science (3)
- Elective (free) (3)

### Year 3, fall
- Phy 13, 14 (5)
- Approved BioS elective (3)
- Writing Intensive (3)
- Elective (free) (3)

### Year 1, spring
- Arts 1 (1)
- Engl 2 (3)
- Math 52 (3)
- EES 31 (4)
- Math 22 or 52 (3-4)

### Summer 1:
- Elective (free) (3)

### Joint Degree Program in Optometry
In cooperation with the State University of New York, State College of Optometry located in New York City, Lehigh offers a seven-year Bachelor of Arts in Behavioral Neuroscience and Doctor of Optometry (O.D.) Program. Students accepted into the joint degree program are admitted into the behavioral neuroscience major at Lehigh and are simultaneously admitted to candidacy in the SUNY College of Optometry’s professional program of study.

Application to the program occurs when a student applies to Lehigh or while enrolled at Lehigh. Criteria for selection is based upon maturity and motivation; an interest in the basic understanding of the optometric profession; a minimum of 1180 SAT recentered score, 92 high school grade average, and ranked in the top 10% of the high school graduating class. Or, if a first- or second-year student, a minimum overall 3.2 GPA in undergraduate coursework and in all prerequisite math and science courses completed at the time of application with no grade below a C. A committee comprised of representatives from both institutions selects the students for admission into the program.

Students will matriculate at Lehigh for three years during which time a minimum of 91 credit hours are earned toward the baccalaureate degree. Upon maintaining a minimum 3.2 GPA in the math and science prerequisites, attaining total science scores of 320 or above on the Optometry Admissions Test (OAT), and passing reasonable personal interview standards, these students will be admitted to the SUNY College of Optometry at the completion of their third year at Lehigh. All science and math prerequisite courses must be satisfied with a C or higher.

Students must submit a formal application, transcripts, and recommendations at this time. After successfully completing all first-year coursework at the college of optometry, a BA degree in behavioral neuroscience will be granted by Lehigh.

The optometry school reserves the right to withdraw an acceptance if academic or personal concerns cause the school to question a student’s ability to function as an optometrist.
Application for admission to the program for incoming students is made through the Lehigh Office of Admissions. Applications deadline is January 1.

Year 1, fall
Art 1 (1)  Eng 2 (3)
Engl 1 (3)  Chm 21, 22 (5)
EES 31 (4)  Math 52 (3)
Math 51 (4)  Bios 31, 32 (4)
Psyc 1 (3)  FYC (1-4)

Year 2, fall
BioS 101 (3)  Psyc 110 (3)
BioS 177 (3)  Chm 52, 58 (4)
Chm 51, 53 (4)  Bios 375 (3)
Humanities elective (4)  Social Science elective (4)
Social Science elective (4)

Year 3, fall
BioS 277 or BioS 210 (3)  Phy 13, 14 (4)
BioS 382 (3)  Humanities elective (4)
Chm 31 (3)  Approved Bios elective (3)
Phy 11, 12 (5)  Elective (free) (3)

Health and Human Development Minor
The minor in health and human development, located primarily within the College of Arts and Sciences, is an interdisciplinary program designed to provide insight into the social scientific aspects of health issues through the human life cycle. While this minor program is open to anyone in the three undergraduate colleges, it may be of particular interest to students preparing for careers in any aspect of health care, social work, and child or adult development.

The program is administered through the Program in Health and Human Development, an interdisciplinary group of faculty members who have research interests in this area. Current research studies cover all aspects of the life cycle, including the health dimensions of both normal and abnormal child development, reproductive health issues, adult life crises such as illness and loss, and dimensions of aging. Students are able to serve as research assistants in some of these studies.

The minor consists of a minimum of 15 credit hours chosen in consultation with the program director, Donna Kosteva, in the Office of Career Services.

required courses (6 credit hours)
SSP 160  Medicine and Society (3) and
Psyc 107  Child Development (3) or
Psyc/SSP 109  Adulthood and Aging (3)

elective courses (9 credit hours) chosen from three different disciplines:
Anth 321  Anthropology of Physical and Mental Health (3)
Phil 116  Bioethics (3)
Psyc 107  Child Development (3)
Psyc/SSP 109  Adulthood and Aging
Psyc 305  Abnormal Psychology (3)
Psyc 351  Cognitive Development in Childhood (3)
Psyc 361  Personality & Social Development in Adulthood (3)
Psyc 363  Personality and Social Development in Childhood (3)
SSP 152  Alcohol, Science & Society (3)
SSP 160  Medicine and Society (3)
SSP 162  AIDS and Society (3)
SSP 366  Sociology of Aging (3)
SSP 341/WS 341  Women and Health (3)

Education Minor
The education minor helps undergraduates explore career options in school teaching or other professional careers with elementary, secondary, or special-education students. The minor may accelerate entry into a teaching career because appropriate credits from the minor may be applied toward completion of teacher-certification credits for those admitted to Lehigh's graduate-level Teacher Intern Program. The minor offers a systematic background of professional education experiences, coordinating practicum activities with theory courses designed to provide a foundation for future educational studies. Its focus is exploratory. No career decision is required but the minor is provided for those with a serious interest in considering the teaching profession.

The experiences of the minor are intended to enrich an individual's understanding of education as a central intellectual activity of our culture and to provide self-understanding of one's own potential as an educator.

An undergraduate may take one or all of these courses during the junior and senior years with the approval of the adviser and minimum GPA of 2.75. Completion of the minor does not assure admission to the Teacher Intern Program to become a certified professional. However, if the student passes the screening process on the basis of previous work and interviews, he or she may enter the intern program with advanced standing toward certification.

The program coordinator is Lynn Columba, Program Coordinator, College of Education, Mountaintop Campus, 111 Research Drive.

Fifteen credit hours are chosen from among the following courses for those in the education minor:

Educ 312  Classroom Practice (1)
Educ 314  Intern Seminar (2)
Educ 394  Special Topics in Instruction and Curriculum (3)
Educ 429  Child Development (3)
Educ 441  Youth in Society (3)
Elective  Education course (appropriate to student's objective (3)

The Five-Year B.A. or B.S./M.A. or M.Ed. Combined Degree and Teacher Certification Program
The College of Arts and Sciences and the College of Education offer a five-year degree program that is designed to allow students to earn both a bachelor's degree and a master's degree in five years instead of the traditional six.

The combined degree program leads to either a B.A. or B.S. degree in an academic discipline, and an M.A. or M.Ed. degree in either elementary or secondary education. In addition, an Instructional I teaching certificate from the Pennsylvania Department of Education is earned. These certification areas are:
- Elementary Education
- Secondary Education:
  - Biology
  - Chemistry
  - Earth and Space Science
  - English
  - French
  - General Science
  - German
  - Mathematics
  - Physics
  - Social Studies
  - Spanish

Freshmen are able to apply for admission into the program during their second semester. Those accepted will begin their
education courses in the second semester of their sophomore year. Sophomores who wish to enter the program will complete their introductory courses in the summer between their sophomore and junior years. Accommodations can be made for transfer students.

Criteria for admission to the program include:
- A demonstrable commitment to learning and intellectual growth
- An expressed interest in teaching as a career
- Previous experience in working with young people; this can be gained in the summer between freshman and sophomore years.

Students seeking formal admission to the program after one year of study must have:
- Satisfactorily completed Educ 312 and 314 (Note: students entering the program in their junior year will then take these courses)
- Declared a major(s) and been assigned an advisor in the College of Arts and Sciences
- Two letters of reference
- At the end of their junior year, students must have successfully completed Educ 398.

In the last semester of their senior year, students must complete an application for advancement to graduate standing in the College of Education, including:
- A minimum cumulative 2.75 GPA
- Satisfactory experience in all field experiences
- Completion of a graduate application form
- One letter of recommendation addressing the candidates' potential as a teacher
- A master's program approval form should be completed upon admission to the graduate program

For information students should contact Professor Lynn Columba, Program Coordinator, College of Education, Mountaintop Campus, 111 Research Drive.

College of Business and Economics

Richard M. Durand, Ph.D., dean
Therese A. Maskulka, associate dean, director of undergraduate programs; Kathleen A. Tregler, associate dean, director of MBA program; Kenneth P. Sinclair, chair, department of accounting, Thomas I. Hyclak, chair, department of economics, James A. Greenleaf, chair, department of finance and law, John E. Stevens, chair, department of management and marketing, Michael G. Kolchin, director, graduate and professional education; James A. Dearden, director, Ph.D. program.

The College of Business and Economics offers the bachelor of science degree in business and economics, which couples a liberal educational background with an understanding of the complexities and processes of management. It can serve as the basis for a career in business or for professional studies in fields such as law, business, or related fields.

The undergraduate business program, undergraduate accounting program, and MBA program are accredited by the American Assembly of Collegiate Schools of Business (AACSB), of which the College of Business and Economics is a member. The college offers an undergraduate education designed to provide an understanding of the complexities of the managerial process in society, both within and outside the business firm.

The College of Business and Economics consists of four departments: accounting, economics, finance and law, and management and marketing. Undergraduate majors are offered in accounting, business information systems, finance, management and marketing. The Department of Economics offers a major in the College of Business and Economics as well as a major in the College of Arts and Sciences.

Many of the most difficult societal problems today involve decision-making, conflict resolution, and the efficient and effective management of human, financial and physical resources. The study of business and economics provides a basis for understanding and developing solutions to these problems.

Thus the college's undergraduate business programs stress analytical and communication skills, and problem-solving techniques. Educational breadth equivalent to many liberal arts programs is accompanied by in-depth study of business processes such as accounting information systems, financial flows and markets, management processes, and the impact of economic forces upon business and social issues.

Goals of the College

The mission of Lehigh University's College of Business and Economics is to provide educational programs at the undergraduate and graduate levels that prepare students for the increasingly complex and globally competitive environment of the 21st century. This environment will be characterized by rapid and continuous changes in both technology and in the structures of organizations that employ our graduates. These graduates may find themselves repeatedly changing employers and even careers; they will work and live with colleagues from diverse cultural backgrounds. Hence our educational programs must provide them not only with basic entry-level technical knowledge and professional skills, but also broader intellectual capacities that will enable them to thrive during a lifetime of dramatic change.

- The objectives of the undergraduate education we provide are as follows:
  - To stimulate student interest in basic business and economic principles of resource allocation, financial management, management of human and physical resources, information systems, financial and managerial accounting, and pricing and distribution through a common body of knowledge;
  - To provide breadth of appreciation of the scientific, technological, social, and human features of the global environment of business;
  - To develop intellectual tools which permit rigorous analysis of business problems and foster a capacity for continuing lifelong learning;
  - To offer advanced courses for upperclass students as a prelude to a professional career or to graduate study;
  - To provide each student, through his or her major, an in-depth learning experience in at least one area of business or economics, such as accounting, business information systems, economics, finance, management, or marketing;
  - To enhance written and oral communication and critical thinking skills.

Breadth of Study

The integrated undergraduate programs in the College of Business and Economics are designed to provide—through outstanding teaching, innovative curriculum, and opportunities for all students to have personal interaction with practitioners—educational experiences that clearly demonstrate the comparative advantage of Lehigh's academic programs for students majoring in accounting, economics, finance, information systems, management and marketing.

This education in fundamental principles and problem-solving techniques provides graduates with various options. Some students choosing this curriculum have already settled upon business careers. Others will use it as a base for further professional studies in law, graduate business schools, or specialized graduate training in economics, operations research, or other related fields. Still others go into administrative careers
in government or nonprofit institutions such as hospitals and universities. Others apply their talents to professional accounting, financial investment, or management consulting careers.

Business today cannot be approached with narrow, superficial vocational training. Everywhere, organizations are affected by local, national and international economic trends as evidenced by the complex cultural, social and ethical issues today's global marketplace presents. Thus a strong basis in the social sciences is essential to understanding the nature of business organizations. Students must also be familiar with physical sciences and technology and with the ways in which mathematics and computer systems are essential elements of modern decision-making processes. The undergraduate program in business and economics provides an introduction to all of these academic areas.

**Variety of Options**

Students preparing for careers in the 21st century must be provided with options to sample the insights and wisdom of a wide variety of academic disciplines outside of business. At Lehigh, this important exposure to science, language, and the arts and humanities is accomplished by distribution requirements, within each of which the student has wide choice. In addition, students have 33 credits of free electives, 24 of which must be taken outside the College of Business and Economics.

The degree of bachelor of science in business and economics may also lead to achievement of the master of business administration degree at Lehigh or another institution. In addition to the master of business administration, the college also offers the following graduate degrees: doctor of philosophy, master of science in economics, master of science in business and economics, master of science in management science, and master of science in management of technology. These are described in Section IV.

**Centers and Institutes**

The college also oversees research and scholarship in a number of centers and institutes, where graduate and undergraduate students work closely with faculty members. These include: Diamond Center for Economic Education, Iacocca Institute, Center for Innovation Management Studies, Martindale Center for the Study of Private Enterprise, Institute for the Study of Commodities, Philip Rauch Center for Business Communications, Goodman Center for Real Estate Studies, and Musser Center for Entrepreneurship.

**Bachelor of Science in Business and Economics**

To obtain the bachelor of science degree in business and economics, 124 credit hours are required. A writing requirement, which is included within the required 124 credit hours, is also a part of the college curriculum.

**Planning Courses of Study**

**Freshman Year**

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**Sophomore Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
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<tbody>
<tr>
<td>Bus 4</td>
<td>1</td>
</tr>
<tr>
<td>Mkt 107</td>
<td>2</td>
</tr>
<tr>
<td>Mkt 111</td>
<td>3</td>
</tr>
<tr>
<td>Eco 115</td>
<td>3</td>
</tr>
<tr>
<td>Fin 125</td>
<td>3</td>
</tr>
<tr>
<td>Eco 129</td>
<td>4</td>
</tr>
<tr>
<td><strong>Electives</strong></td>
<td><strong>33</strong></td>
</tr>
</tbody>
</table>

**Junior Year**

<table>
<thead>
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<tbody>
<tr>
<td>Law 201</td>
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</tr>
<tr>
<td>BIS 211</td>
<td>3</td>
</tr>
<tr>
<td>or Acct 311</td>
<td>3</td>
</tr>
<tr>
<td>Mgt 280</td>
<td>4</td>
</tr>
<tr>
<td><strong>Distribution</strong></td>
<td><strong>15</strong></td>
</tr>
<tr>
<td><strong>Major Program</strong></td>
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</table>

**Senior Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mgt 301</td>
<td>3</td>
</tr>
<tr>
<td>or Mgt 306</td>
<td>3</td>
</tr>
<tr>
<td><strong>Electives</strong></td>
<td><strong>33</strong></td>
</tr>
</tbody>
</table>

**Major Program (15 credits or 18 credits for accounting majors)**

Before the end of the first semester of the junior year, students select a major consisting of sequential or related courses in one of the following six major programs: accounting, economics, business information systems, management, and marketing. A GPA of 2.0 or higher in the major program is required for graduation.

**Distribution Requirements (15 credits)**

Students are required to take six (6) credits of humanities, six (6) credits of social science, and three (3) credits of science for a total of 15 credits of distribution requirements. Students should refer to the catalog to determine which course offerings may be taken to satisfy this requirement.

**Electives (33 credits)**

Students will earn 33 credits of “free” electives; a maximum of nine credits may be taken from other course work in the College of Business and Economics. The remaining 24 credits are to be taken outside the College of Business and Economics. Of these 24 credits, six credits may be economics courses with a social science (ss) designation.

**Math Requirements**

1. **Calculus and Linear Algebra Combination**
   - Survey of Calculus I (Math 51)
   - Calculus I (Math 21)
   - Honors Calculus I (Math 31)
   - Linear Algebra Component:
     - Linear Algebra for Business and Economics (Math 61)
   - Introduction to Finite Mathematics (Math 9)
   - Survey of Linear Algebra (Math 43)
   - Linear Methods (Math 205)

2. **Double Calculus Combination**
   - Survey of Calculus I and II (Math 51 and 52)
   - Calculus I and II (Math 21 and 22)
   - Honors Calculus I and II (Math 31 and 32)

In the College of Business and Economics, the pass-fail option is available for elective courses only. Students desiring Lehigh credit for courses taken at other institutions must file a petition obtaining approval of appropriate Lehigh academic departments in advance.

**College of Education**

The university’s College of Education offers opportunities for advanced study in the field of education. For information, see Graduate Study in Education, Section IV, or College of Education, Section V.
P.C. Rossin College of Engineering and Applied Science

John Chen, dean
Richard N. Weisman, associate dean
Philip A. Blythe, associate dean

The P.C. Rossin College of Engineering and Applied Science offers the bachelor of science degree in 13 programs, combining a strong background in sciences and mathematics with requirements in humanities and social sciences. Students in college programs learn principles they can apply immediately in professional work; those who plan on further academic experience can design a curriculum centering on interests they will pursue in graduate school.

Major Subjects
The P.C. Rossin College of Engineering and Applied Science includes six departments and offers undergraduate and graduate degree programs at the bachelor, master, and doctor of philosophy levels.

The undergraduate degree programs leading to the bachelor of science degree are:

- biochemistry
- chemical engineering*
- chemistry
- civil engineering*
- computer engineering*
- computer science**
- electrical engineering*
- engineering mechanics
- engineering physics
- fundamental sciences
- industrial engineering*
- materials science and engineering*
- mechanical engineering*
  *Accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology.
  **Accredited by the Computing Science Accreditation Board, Inc.

Programs in chemistry and physics have been approved by the faculty program review committee in these disciplines.

Information about each of these programs may be found under alphabetical listings in Section V.

Each of the curricula includes course requirements in the physical sciences, mathematics, engineering, and the advanced engineering or science course work essential for the particular degree. In addition, each curriculum requires study in humanities and social sciences (HSS).

Declaration and Change of Curriculum
In the second semester of the freshman year, at preregistration for the sophomore year, students usually indicate their choice of curriculum. However, since the sophomore year programs for several curricula are very much alike, it is possible to transfer from one curriculum to another as late as the end of the sophomore year. This is done by filing a new declaration of major form. There are instances where such a transfer may require one or two courses to be taken during a summer session at Lehigh or elsewhere.

Undergraduates with interests in such topical areas as environmental biotechnology or aerospace engineering may pursue their interests through electives provided in each of the curricula. Effective preparation for graduate study in such specialties consists of basic programs in engineering and science, along with electives especially chosen for the field of interest. Such electives are chosen from among all the offerings of the university and are usually taken during the senior year.

Free Electives
The college, through its advisers, is prepared to help students to use the credit hours of "free electives" that, along with other electives in the curriculum, may be used to develop a program of personal interest. Free electives may be satisfied by taking regular course offerings or up to six credit hours from Mus 21-79, or up to six credit hours from Jour 1-8, or up to six credit hours of advanced ROTC courses.

Qualified juniors in the college planning to continue their formal education in graduate school are urged to take advantage of the flexibility in their programs and design their senior-year "free elective" opportunities in a manner that provides an effective foundation for a graduate program. Students who plan their programs in this manner can, upon recommendation of the department, receive credit toward their degree for up to six hours of graduate-level courses.

Technical Minors
Minors are offered in technical or scientific specialties that are not normally included within the standard curricula. Each minor program contains at least 15 credit hours of technical and/or scientific courses. Often these courses can be chosen as approved electives in the student's major curriculum; others are chosen as free electives.

The student interested in a technical minor should contact the associate chair of the department in which the minor is desired for specific degree requirements.

Recommended Freshman Year In Engineering and Applied Science
A recommended outline of courses for the freshman year, which satisfies requirements for all students in the college, is shown below. For schedules of the courses required in the following three years, refer to Section V.

Freshman year, first semester (15-16 credits)
- Engl1 Composition and Literature (3)
- Chm 21, 22 Introductory Chemical Principles and Laboratory (5) or
- Phy 11, 12 Introductory Physics I and Laboratory (5)
- Math 21 Calculus I (4)
- Engr 1/E elective Engineering Computations (3) or Humanities/ Social Sciences or free elective (2-4) and Engineering 2, Introduction to Engineering (1)

Freshman year, second semester (15-16 credits)
- Engl2 Composition and Literature: Fiction, Drama, Poetry (3)
- Phy 11, 12 Introductory Physics I and Laboratory (5) or
- Chm 21, 22 Introductory Chemical Principles and Lab (5)
- Math 22 Calculus II (4)
- Engr 1/E elective Engineering Computations (3) or Humanities/ Social Sciences or free elective (2-4) and Engineering 2, Introduction to Engineering (1)

Humanities/Social Sciences (HSS)
Requirement for all Accredited Engineering Majors

Basic Requirement: English and Economics. (Three courses totaling a minimum of ten credit hours):
Students must complete English 1 or 3, English 2,4,5,6,8 or 10, and Economics 1.
Advanced Requirement: Breadth and Depth. 13 Credits in courses designated as H (humanities) or SS (social science), not including one-credit performance courses, with the following restrictions:
1. At least eight credits must be in a common discipline and from the same department or program. At least three of these credits must be at the 100-level or above, or at the intermediate level or above for a single modern foreign language.
2. At least three credits in a discipline different from, and not cross-listed with, the discipline employed to satisfy the concentration requirement above.
3. At least three credits must be designated as H.
4. HSS Credit is not given for a first elementary-level modern foreign language course (e.g. Spanish 1) until after the second elementary-level course (e.g. Spanish 2) is completed satisfactorily.
5. None of the courses taken to satisfy the HSS requirement can be taken Pass/Fail.

Minors in Humanities/Social Sciences
For greater emphasis in a particular area, a student may choose to complete a minor in Humanities and Social Sciences (HSS). Specific requirements may be found under the heading Minors in the College. Because students must fulfill the HSS requirements, this will result in taking as many as seven HSS courses. Therefore, a student electing a minor must use personal (free) electives. Each curriculum in the college contains a minimum of two such unrestricted electives.

Written permission to pursue a minor in HSS must be obtained from the sponsoring department, and the student's academic advisor, and filed with the registrar. A student successfully completing a HSS minor will receive recognition of this accomplishment on his or her transcript.

Centers and Institutes
Faculty and students in the college also have research and scholarship activities in a number of centers and institutes, where graduate and undergraduate students work closely with faculty members. These include: Center for Advanced Technology for Large Structural Systems, Biopharmaceutical Technology Institute, Chemical Process Modeling and Control Center, Emulsion Polymers Institute, Energy Research Center, Enterprise Systems Center, Fritz Laboratory, Institute of Thermo-Fluid Engineering and Science, Materials Research Center, Sherman Fairchild Center for Solid-State Studies, Polymer Interfaces Center, Polymer Science and Engineering Center, Structural Stability Research Council, Council on Tall Buildings and Urban Habitat, Center for Manufacturing Systems Engineering, Ben Franklin Center, Manufacturers Resource Center.

Special Undergraduate Academic Opportunities

The academic programs in the colleges are supplemented by five-year, two-degree programs as well as opportunities for advanced, foreign, and experiential study.

Arts-Engineering Option
The curriculum in arts-engineering is designed for students wanting a professional education in a field of engineering and also the opportunity to study a second field.

Arts-engineers fulfill all requirements for the professional engineering degree for which they are working. However, the first three years of science and engineering courses are scheduled over four years for the arts-engineer. During this period the arts-engineer is a student in the College of Arts and Sciences pursuing a bachelor of arts or bachelor of science major program.

In many instances it may be advisable to take the two degrees at the end of the fifth year. Arts-engineers working towards the bachelor of science in biology, computer science, environmental science, geological sciences, geophysics, molecular biology, and statistics are advised to pay special attention to the engineering humanities and social science requirements, which must be met in time for the student to qualify for the B.S. in engineering.

Arts-engineers have the same opportunities for multiple majors and special interdisciplinary majors as are available to students working for the baccalaureate (B.S. or B.A. degree only) in the College of Arts and Sciences. Additional information may be obtained by contacting Prof. Daniel Zeroka, 496 Seeley Mudd Building.

Bachelor/Master Degree Programs

Of increasing interest to undergraduates are the two-degree programs that may lead to both a bachelor and a master's degree in five years. Because Lehigh's well-established graduate programs are closely integrated with the undergraduate programs, it is possible to consider programs leading to the arts/master of business administration degree and the engineering/master of science in material science, among others. The five-year program in the School of Education enables those receiving a B.A. or B.S. degree to accomplish professional teacher training and serve as salaried interns in public schools. After the completion of one year of full-time teaching, secondary teachers can receive the master of arts and elementary teachers can receive the master of education degrees.

Many other five-year, graduate-level combination programs exist, and students are advised to consult with their adviser in planning such programs.

Interdisciplinary Programs

The university's interdisciplinary programs are designed to cross the boundaries between colleges to accommodate new and developing fields as well as the interests of students. They include such programs as the following:

Africana Studies. A program offering a minor is available to students interested in exploring various aspects of the African American experience. Courses covering African American art, history, literature, music, and society are offered. The program is complemented with a lecture, film, and arts series that highlights the richness and diversity of black culture.

Science, Technology and Society Program (STS). Faculty from all three colleges explore the interrelationships between science and technological advancement and the quality of human life in the popular STS program.

Office of International Education

318 Whitaker, S. E. Packer Ave., Bethlehem, PA, 18015-3198; (610) 758-4859. Fax (610) 758-5156. E-mail: intnl@lehigh.edu.

www.lehigh.edu/~intnl/intnl.html

Lehigh fosters an environment that welcomes and encourages the international exchange of students and scholars, and that integrates their global experience into the academic and cultural community. The Office of International Education (OIE) is a university-wide resource for students and scholars from abroad, for U.S. students studying abroad, for U.S. students and faculty who are interested in the global focus, and for international alumni and advancement. Its mission is to advance, promote and serve the Lehigh community through the international dimension of the university by: maintaining the office as a
university-wide international and Lehigh Abroad resource; providing services and advising specific to the needs of international students and scholars, and to students, faculty and staff going abroad; integrating international students and scholars and Lehigh Abroad returns into the international dimension of the university; and maintaining the Lehigh Global Network of alumni and friends.

International Students and Scholars
Gisela M. Nansteel, Immigration Specialist, 318 Whitaker, 5 E. Packer Ave., Bethlehem, PA, 18015-3198; (610) 758-4859, Fax.(610)758-5156, E-mail: gmn@lehigh.edu.
www.lehigh.edu/~intnl/intnl.html

OIE serves the unique needs of foreign nationals who come to Lehigh as students, scholars, faculty and staff members, and their families. More than 700 people from over 65 nations currently live, work and study on our campus. OIE offers advising on immigration, visa, and personal matters. The office acts as a liaison with other offices and departments on campus, and with national and international agencies.

A variety of cross-cultural programs are initiated by the OIE and the Global Union, including a combined undergraduate and graduate orientation, an International Advisory Committee, spouse conversation groups, seminars on immigration matters, international tax advising, the Halloween Party, Thanksgiving Dinner, and the International Bazaar. The office also sponsors the Cultural Exchange Committee, the International Club, and Phi Beta Delta.

The year for international students and scholars at Lehigh begins with the International Orientation. Orientation takes place in conjunction with other programs offered by the undergraduate admissions office and/or graduate departments, starting immediately before the university-wide orientation at the beginning of each semester. Orientation for international undergraduates, LIFT - Lehigh International Freshman and Transfers is strongly recommended for all new international undergraduates. Issues discussed include filing for a social security number, opening a banking account in the United States, health insurance, and adjustment to university life at Lehigh and to the United States. International Orientation is a time to become accustomed to life in America, and to meet other foreign students. Orientation closes with a picnic in honor of the entire international population at Lehigh, hosted by the university president.

Throughout the year, special events are held to promote the international community at Lehigh. These culminate in the International Bazaar in April. Sponsored by the OIE and the Global Union, the Bazaar is the international students' opportunity to share their cultures and traditions with the university. Student organizations offer their favorite home country foods, dances, art work, culture and a fashion show in an event which is unrivaled for international flavor.

The electronic bulletin board (INTERNAT) features information of interest to the international community including news about cultural events, immigration matters, tax help, etc. OIE also maintains an electronic mailing list which contains the names of all the foreign students and scholars on campus. Regular updates are sent through e-mail which keep the international population abreast of current events. A Handbook for International Students and Scholars is available for all.

Lehigh University is committed to providing an international experience which is rivaled by none. To this end, an International Administration Team has been assembled to actively support and promote the international dimension of the campus. Its membership represents a cross section of the university, including Lehigh Abroad, the offices of student affairs, admissions, development, alumni, and ESL. The team works to enhance the Lehigh experience for foreign nationals by providing quality services to students, scholars, alumni, parents and families.

Additional Special Services for International Students

Career Services: Advising and special workshops for careers for international students are provided.

Food Service: For undergraduate students on the meal plan, menus meet the dietary needs of the students. There is a stir fry bar and balanced meals for vegetarian diets.

Health Center: Fully staffed medical personnel meet both the physical and personal needs of all students. The Counseling Center has special services for international students.

Housing: Some residence halls are open for vacation time periods.

Immigration/Visa Advising: Complete service.

International Club: An undergraduate campus-wide club for all international and U.S. students which plans social activities and helps with orientation.

International Partners Program: International students are paired with volunteer students and staff to get together regularly for social and learning activities.

Learning Center: Tutors are provided in writing, math and science.

Lehigh Global Network: An alumni outreach program is dedicated to establishing alumni organizations world-wide.

National Clubs: Several home country clubs from all regions of the world are established on campus. They form an important part of the cross-cultural dimension of the campus, providing social events, films, and international dialogue.

Phi Beta Delta, International Honor Society: Lehigh's Beta Pi chapter of Phi Beta Delta, the international honorary society with chapters across the U.S., is an important international organization on campus. The purpose of the society is to honor those involved in high academic achievement and service in the international dimension, and to foster international exchange on campus. The honor society has three categories of membership: international students who have demonstrated high scholastic achievement at Lehigh; U.S. students who have demonstrated high scholastic achievement in the pursuit of international studies including study abroad; faculty and staff distinguished in international endeavors.

Religious Services: Services for all the major religions are on campus or nearby, including Muslim, Christian, Jewish, Hindu and Buddhist.

Lehigh Abroad
Casimer Sowa, Associate Director, 343 Whitaker, 5 E. Packer Ave., Bethlehem, PA 18015-3198; (610) 758-3351; Fax (610) 758-5156; E-mail cms2@lehigh.edu.
www.lehigh.edu/~incis/incis.html

The Lehigh Abroad office maintains a list of more than 50 approved semester and year programs in over 40 countries around the world where Lehigh students can study and receive Lehigh credit. The programs are regularly evaluated and monitored by faculty in order to ensure high academic quality.

The Lehigh Abroad office advises students and refers them to the appropriate faculty or staff members. Group and individual advising sessions take place every week. Lehigh Abroad also provides a series of required pre-departure orientation meetings for all students going abroad and continuous registration at Lehigh. Program information is located in the Lehigh Abroad Resource Room, 343 Whitaker Lab.

Additionally, Lehigh University maintains formal exchange agreements with universities in Australia, Belgium, Mexico, United Kingdom, France, Hong Kong and Japan. Students are selected through faculty interviews for these programs.

Architecture and urban studies students who qualify can earn credits with grades on the Columbia University program, "The Shape of Two Cities: New York and Paris," which offers a semester of study in each location.

The Philip and Muriel Berman Center for Jewish Studies sponsors semester and year programs in Israel in cooperation with Tel Aviv University and Hebrew University in Jerusalem.
Contact: Center for Jewish Studies, 324 Maginnes, 9 West Packer Avenue, Bethlehem, PA 18015; (610) 758-4869.

**Fulbright Scholarships:** The Lehigh Abroad office promotes and advises students who wish to apply for the Fulbright Scholarship. Fulbright provides a year of postgraduate study/research abroad for students with a bachelor's degree.

**Foreign Language:** Students are encouraged to study in the language of their program country. Most programs in non-English speaking areas require four or five college semesters of language study. The Department of Modern Languages and Literature (MLL) offers limited merit scholarships. Contact MLL, Maginnes Hall, 9 W. Packer Ave., Bethlehem, PA 18015; (610) 758-3090.

**Requirements:** A minimum GPA of 2.7 and good judicial standing are required to study abroad for a semester or year. A student with a GPA below 2.7 may petition for a waiver through the Lehigh Abroad Office to the Committee on the Standing of Students.

**Applications:** Students who receive Lehigh academic credit for a study abroad program must submit an application through Lehigh Abroad. Applicants are required to consult with academic advisors, have courses approved by departments, and in some cases request recommendations by faculty.

**Academic Credit:** Academic credit is given for programs approved by Lehigh faculty only.

**Fees:** Lehigh endeavors to make study abroad available to all students. Financial aid, as determined by the financial aid office, goes with the student. In addition, Lehigh usually provides partial travel grants to the study abroad sites. Lehigh requires the payment of Lehigh's tuition, minus the financial aid, for all students going abroad who receive Lehigh credit. Lehigh Abroad then pays the student tuition fees to the program abroad. In some cases, room and board are handled in the same way.

**Deadlines:**
- Fall or year programs: February 1
- Spring programs: September 15

**Note:** Programs in Australia have a rolling admission process. For some sites, students may need to submit applications eight (8) months in advance.

**Summer Programs:**
Lehigh offers several faculty-led summer and winter programs each year. The number of programs and academic offerings can vary from year to year. Past destinations included Belgium, Costa Rica, Czech Republic, England, France, Ireland, Italy, Ghana, Spain and China. Contact the Lehigh Abroad Office for program details.

Lehigh Abroad also maintains a list of approved summer study abroad programs offered through various institutions. The office advises students on programs appropriate for their field of study and procedures for summer programs and credit transfer. Study abroad programs are approved through the Lehigh Abroad Faculty Policy Board.

**Deadlines:**
- Preliminary application: March 1
- Lehigh University sponsors through the Lehigh Valley Association of Independent Colleges (LVAIC), several six-week summer language programs in Europe and Mexico. Credits and grades transfer to Lehigh and are counted in the student's GPA.

**The Philip and Muriel Berman Center for Jewish Studies**

The Global Union is a collaboration of more than 25 student clubs and organizations that promote global awareness and cultural understanding within the Lehigh community. There are more than 600 members of the Global Union from over 30 countries, including two-thirds from the United States.

Located on the top floor lounge of Lamberton Hall, the Global Union hosts panel discussions on world issues, dinners and cultural festivals, musical performances, and a language exchange program. Annual events include the Global Symposium, the International Bazaar, and orientation for all international students. All events at the Global Union are open to the entire Lehigh community.

The lounge also has a TV/VCR, stereo, comfortable couches and a microwave, and can be used for meetings, quiet study or film presentations.

The main floor of Lamberton Hall or the Global Union lounge can be reserved by calling (610) 758-4505 ten business days before the proposed event.

For more information regarding the Global Union, check our website at www.lehigh.edu/-inglobal/

**English as a Second Language**
Judith Rance-Roney, Director, 33 Coppee Drive, Bethlehem, PA, 18015; (610) 758-6099 www.lehigh.edu/~esl

The English as a Second Language Program (ESL) offers academic semester and summer courses for undergraduate and graduate students and their families. In addition, academic support is provided for ESL students through conversation groups and low-cost language enrichment courses.

**English Department Courses.** After reviewing placement test results, undergraduates accepted by the ESL program may take English 3 and English 5 (ESL) in substitution for English 1 and 2. (Refer to the English department course listings.)

**ESL Credit Courses.** Both undergraduate and graduate students may select from a variety of supplemental ESL credit courses in conversation, accent reduction, reading, and writing offered throughout the year. (Refer to the English as a Second Language course offerings.)

**Intensive ESL Summer Program.** The STEP/UP Program provides an intensive academic ESL experience for both enrolled Lehigh students and for other students preparing to enter a U.S. university or who need professional English skills. STEP/UP enhances English skill in academic reading and writing, formal academic language, and an orientation to academic culture. Students entering STEP/UP should be at an intermediate or advanced English level.

**Non-credit ESL.** The TLC (The Lehigh Community) Program offers non-credit enrichment ESL courses at a low cost to enrolled students and family members. TLC is also open to members of the surrounding community. Contact the ESL office for a schedule.

**International Multimedia Resource Center**
Johanna Brans, Instructional Technology Specialist, 473 Maginnes; (610) 758-6134, 6295.

The International Multimedia Resource Center, located in Maginnes Hall, provides a diversity of services ranging from multimedia to telecommunications. Under the auspices of Information Resources, working directly with Media Production and the Media Center, in collaboration with the College of Arts and Sciences, and Modern Languages and Literature, the IMRC maintains a multimedia computing center (470 Maginnes Hall) equipped with state-of-the-art multimedia computers, a head end room (473) and the World View Room (490 Maginnes Hall) that broadcasts international, historical, and cultural events on our wide screen television. As a resource center, the IMRC supports the efforts of faculty and staff in the design, construction and application of either original or off-the-shelf...
multimedia presentations and projects. New CD ROM based immersive software programs enhance language learning. Student-centered web-research projects occur through partnerships with various faculty members throughout the year. Web utilization, research and design workshops are held regularly, focusing on diverse software web, desktop and design applications. An extensive collection of international audio, video and multimedia programs is maintained. Moreover, the IMRC sponsors business, university, and international broadcasting, as well as teleconferencing events through satellite and videoconferencing technologies. The IMRC also maintains the two broadcast video channels at Lehigh: the Academic Channel (Channel 21: including international news (SCOLA), student produced programming, academic programs and labs, sports and special events, etc.) and the Movie Channel (Channel 22: popular, independent, and foreign movies programmed by a student-elected committee). As a ‘Window to the World,’ the World View Room shows or hosts daily scheduled international and cultural programs, as well as being open for news watching all day long. Comfortably furnished, the World View Room accommodates 25 - 35 people. A 47 inch large screen television allows easy viewing by all. Newly added is our refurbished (five-meter dish) digital link, which facilitates PBS, ALS and The Business Channel teleconferencing.

Experiential Learning
The accommodation of student interest extends beyond regular departmental offerings. Hands-on experiences in learning enrich classroom instruction. Each of the three colleges offers a number of such experiences to undergraduates. Among them:

The Philadelphia Urban Semester. Undergraduates in all fields of study can earn 16 Lehigh credit hours by spending a semester studying in the nation’s fourth-largest metropolis. They live, work, and study with other students from two dozen other institutions, supervised by faculty of the Great Lakes Colleges Association. This consortium of such leading midwestern institutions as DePauw, Kenyon, Oberlin, and Wooster is a recognized leader in providing extra-curricular academic programs both here and abroad.

The curriculum consists of two four-credit seminars and an eight-credit internship. All students are enrolled in a core “Seminar on the City” which introduces them to the field of urban affairs and to Philadelphia. The second seminar is elected from a half-dozen more specialized urban topics; recent choices available have included “Folklore in Philadelphia,” “Art in the City” (which meet each week at a different site), and “Justice.” Internships involve working four days weekly in a public or private placement which tests the student’s aptitude in a variety of practical ways while enhancing appreciation of city life.

The Washington Semester. Opportunity is available each year for six juniors or seniors to spend a term studying in Washington, D.C., in cooperation with American University. Lehigh University is a member with 180 other colleges and universities.

Students enroll at Lehigh but spend the semester in residence at American University with the students from other participating colleges.

The curriculum consists of national-government seminars, an internship, and a written research project. Besides the national government program, the student may choose other program offerings such as economic policy seminar, journalism, public administration, foreign policy seminar and justice seminar.

Inspection trips. The location of the university in the center of industrial activities of various types affords unusual opportunities for visits to manufacturing plants. Inspection trips to individual plants are a required part of specific courses in various engineering curricula. Written reports may be required. These trips are generally held during the senior year and involve an average expense of $25 to $50.

Credit by Examination
Upon petition and presentation of evidence that he or she has qualified for it, a student already enrolled at Lehigh may be permitted by the standing of students committee to take a special examination for credit towards graduation. Special examinations are granted only for extraordinary reasons and upon petition. There must be adequate supporting evidence of sufficient cause accompanying each petition. There is a fee for all special examinations.

Students taking a special exam after matriculation at Lehigh will have the grade and credits assigned to their permanent Lehigh record. Special exam credit will be counted as in-residence credit and the grade will be used in all grade point average calculations. No special exam will be granted in a course that the student has already taken (except senior reexaminations), or in a course in which the student has already completed more advanced work at Lehigh.

Preparation for Graduate Work
Students planning to continue in graduate programs should take advantage of the flexibility in many undergraduate programs to design an upper-division curriculum that meets requirements in the anticipated graduate program.

The policies of the colleges provide as much flexibility as possible for students who wish to change to new but related fields of study after the baccalaureate degree. Students should consult with their previous program adviser and the department representative of the new field to establish an academic program that will remedy any deficiencies in background.

Apprentice Teaching
The apprentice teaching program is designed to benefit juniors and seniors who wish to learn about teaching under the guidance of an experienced teacher. Apprentices often do a limited amount of supervised lecturing or leading of discussions, assist in making up and evaluating written assignments, and are available for individual consultation with students.

To participate in the apprentice teaching program a student must:
1. Have an over-all cumulative grade point average of 2.80 or better;
2. Have a cumulative grade point average of at least 3.3 and have completed at least two courses in the major field in which apprentice teaching is done;
3. Have previously taken for credit the course or its equivalent in which the apprentice teaching will be done.

A student may register for apprentice teaching only once each semester, only once in a given course, and only twice during a college career.

To register for apprentice teaching each student-teacher partnership will submit an apprentice teaching agreement, indicating the duties and obligations for approval to the department chair and the dean of the student’s college in which the course is taken. This form must be submitted to the registrar before the first day of classes in the semester. To complete the course, the apprentice teachers must submit a written report of their experience to the supervising teacher, who will forward it to the Office of the Provost.

Curricular Flexibility
Choice is a regular part of university life, and encompasses the determination of a college and major, the selection of courses each term, and the development of life goals and career options. Many of these choices are academic in nature. The undergraduate curricula are flexible, designed to accommodate the changing interests and needs of students. Boundaries between colleges are as fluid as possible to provide many options in an educational program. For instance, students may take a bachelor of science (B.S.) degree in the College of Business and Economics or the P.C. Rossin College of Engineering and Applied Science with a minor in journalism in the College of Arts.
and Sciences. There are five-year programs for which degrees are awarded in two colleges.

Transfers between undergraduate colleges is permitted but only after the freshman year. Students considering such a transfer must confer with their advisers to begin the process.

Academic offerings of the various departments are described in Section V. To provide additional flexibility and encourage student initiative and depth of investigation, the university has developed academic alternatives including the following:

**Provisional Courses.** Departments may introduce provisional courses temporarily within a semester, either experimentally or as a response to a contemporary social or scientific issue. If successful, a course may become part of the regular curriculum. Such courses, identified with a 95, 96, 97 or 98 number (preceded by a 1, 2, or 3 indicating level) may sometimes take provisional courses numbered above 100 on a pass/fail basis.

**Independent Study.** Juniors and seniors of ability who wish to concentrate in their chosen field can substitute no more than four or six credit hours of independent, unscheduled work each semester for an equal number of credit hours of elective work required for graduation. Students, in collaboration with the major advisor, with the advice of the departmental chair and consent of the college dean, may structure such a project for study in any curriculum and most major study sequences.

**Pass/Fail Option.** Students have the opportunity to study in areas outside the major field. This option is open to those who are sophomores and above, in good standing, who have declared a major. Courses numbered below 100 will not be eligible for pass/fail. The pass/fail option may not be used for major or minor subject credit toward graduation or for distribution requirements. Consultation with the advisor is required.

**Graduate Courses.** Qualified undergraduates may petition the graduate committee to register for 400-level courses if they are certified by the course instructor and the department chair concerned.

**LVAIC Cross-Registration.** Currently enrolled full-time degree seeking students in good academic standing who have achieved sophomore status may register for up to two courses per term that cannot be scheduled at the home institution at any one of the member institutions (Allentown College of St. Francis de Sales, Cedar Crest College, Lafayette College, Moravian College, and Muhlenberg College). The student must obtain the appropriate approvals of his or her own adviser and the host institution registrar. The courses must be in the normal academic load and not produce an overload.

All grades of courses taken through the LVAIC cross-registration process will be accepted by the home institution and entered on the permanent record, and such grades will be used in computing the grade point average. Credits taken through the cross-registration process will be calculated as in-residence. The number of credit hours assigned to a course is the responsibility of the home institution registrar.

Students may not repeat a course at another LVAIC institution in which they expect to have a Lehigh cumulative grade point average adjustment.

Lehigh University students are not permitted to cross-register for courses in all January intersession programs, the evening program at Muhlenberg College, all weekend courses at Cedar Crest College, or the Access program at Allentown College. All independent study and correspondence courses are prohibited from cross-registration without prior approval of the Lehigh University standing of students Committee.

**SUMMER SESSION**—Lehigh students must have been registered full time in the prior spring semester to be eligible to cross-register for a summer term. A maximum of two courses per session, and 12 credit hours over the course of the entire summer may be rostered. Students may not cross-register for a course being offered at Lehigh during the summer term.

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**The General College Division**

The General College Division supplements the mission of the established undergraduate curricula. The division provides an opportunity for persons not planning to qualify for a degree to pursue work of a general or specialized nature that their preparation and interests make desirable; provides a trial period for those who wish to become candidates for baccalaureate or graduate degrees, but whose preparation does not satisfy the entrance requirements for the established curricula; and provides an opportunity for qualified students to continue their education without being committed to a restricted or specialized program of studies. Courses taken in the General College Division may not be submitted to meet the requirements for a graduate degree.

For admission to the General College Division, the student must submit a special, simplified application to the undergraduate admissions office; the application must be submitted at least one month prior to the start of the semester in which the student hopes to enroll. The applicant must show maturity, seriousness of purpose and evidence of ability to pursue with profit the program of studies he or she desires. The student must have the established prerequisites for courses in which he or she wishes to enroll, and may register for courses up to and including those at the 300-level.

There is no established curriculum for the General College Division. Each student works on a program outlined to meet his or her special needs. Each program must be approved by the registrar, director of the division. Students must obtain permission of the instructor for courses in which they want to enroll. Students in the division are not permitted to take courses using their optional pass/fail grading system, or cross register for courses in the LVAIC.

Students in the division, as non-degree candidates, do not meet the eligibility criteria for federal student aid, under Title IV, including Federal Pell Grants and Federal Stafford Student Loans. Similarly, institutional financial aid also is limited to degree candidates.

Students in the division are not candidates for degrees. A student may transfer to regular matriculated undergraduate status in any of the colleges only upon petition to, and with the approval of, the Committee on the Standing of Students. Transfer to the graduate school is possible only through the normal graduate admission process.

With the exception above, students in the General College Division are subject to the same rules and regulations as students of the university. They pay the tuition and fees established for regularly matriculated students.
Graduate Study

Lehigh began awarding graduate degrees in 1882. The first recipient, T.H. Harcastle, of the Class of 1880, wrote his thesis on Alexander Pope, entitled it The Rights of Man, and read it aloud at commencement in June 1882.

The first Ph.D. was granted in 1893 to Joseph W. Richards, Class of 1886. Richards, who had a background in metallurgy and electrochemistry, taught at Lehigh until his death in 1921.

Women were admitted to the graduate program in 1918 when the faculty and the board of trustees agreed to grant the degrees of M.A. and M.S. to women, provided they attended classes in the late afternoon and on Saturdays "so that the general character of campus life shall not be affected." Three women received graduate degrees in 1921, the first women to complete graduate work at Lehigh. In 1929, the rule was changed, and women were admitted on much the same basis as men.

In 1936, the Graduate School was established to administer the graduate program. The Ph.D., which was temporarily discontinued in 1894, was reinstated in nine departments: chemistry, chemical engineering, civil engineering, geology, history, mathematics, mechanical engineering, metallurgical engineering, and physics. Tomlinson Fort, professor of mathematics, was selected in 1938 as the first dean of the Graduate School.

In 1961, the university officially resolved to strengthen and expand graduate programs university-wide. Since then, graduate work has assumed increased importance and prominence, and facilities and funding have increased tremendously.

In 1995, graduate programs were decentralized and are now administered by the four colleges of the university, as described below.

College of Arts and Sciences

Bobb Carson, dean
Ingrid H. Parson, associate dean of graduate programs

The College of Arts and Sciences offers graduate degrees in the humanities, social sciences, mathematics, and natural sciences. The master of arts, master of science, and the doctor of philosophy degrees are given in most of the traditional academic departments and in some interdisciplinary programs. Advanced degrees may be obtained in the departments of biological sciences, chemistry, English, earth and environmental sciences, history, mathematics, physics, political science, psychology, and sociology. In addition, interdisciplinary degrees are available in American studies and polymers science and engineering.

Although degree requirements vary from department to department, most require a combination of formal coursework and independent research. Students work closely with a faculty adviser in formulating and carrying out their research programs. Students interested in an interdisciplinary approach are admitted to a traditional department but formulate a program of study and research which draws on faculty and facilities in other areas of the college or the university.

Outstanding candidates may qualify for financial support in the form of assistantships as teaching assistants, graduate or research assistants, and scholarships or fellowships.

Information on the various degree programs appears below in chapter V or can be obtained from the Graduate Programs Office, College of Arts and Sciences, 9 West Packer Avenue, Bethlehem, PA 18015 or by visiting our web page at: http://www.lehigh.edu/~incaslgraduate/.

College of Business and Economics

Richard M. Durand, dean
Kathleen A. Trexler, associate dean, director- MBA program

The College of Business and Economics offers the master of science degree in economics; master of business administration with concentrations in finance, management, marketing, international business and management of technology; master of science in management of technology; and the doctor of philosophy degree in business and economics.

There are four departments in the college: Accounting, Economics, Finance and Law, and Management and Marketing. Course descriptions can be found listed under business and economics graduate courses in Section V. More information about the various degree programs appears below. The college publishes a packet describing its graduate programs, which may be obtained by writing to the College of Business, Graduate Programs Office, Rauch Business Center, 621 Taylor Street, Bethlehem, Pa. 18015.

College of Education

Roland K. Yoshida, dean

The College of Education offers the master of arts in education, the master of education, the master of science in education, the educational specialist, the doctor of education, and the doctor of philosophy. More information about these degrees appears below.

The College was established as the School of Education in 1966, elevating it from its former departmental status under the College of Arts and Sciences. In 1985 the school was given its present status as a college, headed by a dean. The College is engaged in the preparation of elementary and secondary teachers in both school and nonschool settings, school and community counselors, counseling psychologists, school psychologists, school administrators, curriculum specialists and supervisors, specialists and supervisors in the education of children and youth with disabilities, teachers of preschool children (especially children with handicaps), and specialists in educational technology.

The College of Education is interested in potential and established leaders in all aspects of educational endeavor. A total of 493 students were involved in advanced study at the master’s and doctoral levels during the 1998-99 academic year.

Through its working relationship with other colleges and universities in eastern Pennsylvania, Lehigh has undertaken to complement existing undergraduate preparation programs by emphasizing study at the graduate level. Off-campus course work and in-service projects are integral parts of many programs.

An intern teaching program is specifically designed for qualified persons who hold bachelor of arts degrees and who desire to enter the field of teaching. Those admitted to this program have the opportunity to accomplish their professional training and serve as interns in the public schools. After two
several semesters of directed full-time study, students may begin the teaching internship. Upon completion of the fifth-year program and the required semesters of intern teaching, these students ordinarily will have completed requirements for the M.A. (secondary teachers) or the M.Ed. (elementary teachers), as well as state certification.

Organization. The College of Education consists of one department, Education and Human Services, and one school, Centennial School. Within the department there are six program areas, each with its own coordinator: counseling psychology, educational leadership, educational technology, school psychology, special education, and teacher education.

Centennial School. The College of Education operates the Centennial School, a laboratory facility for socially and emotionally disturbed children that has both an elementary and a secondary component. Centennial School provides research opportunities as well as practical experience for advanced students in counseling, school psychology, and special education.

Undergraduate minor in education. Upper-level undergraduates are given an opportunity to take a minor in education that combines practical activities with theoretical work and is designed to provide a foundation for further educational studies at the graduate level.

Five-year Programs in Teacher Education. The College of Education offers two programs for students interested in entering the teaching profession. The B.A. / M.A. / M.Ed. programs require that students major in a content area within the College of Arts and Sciences. Students begin their coursework toward their education degree as undergraduates and complete a fifth year during which they obtain a Master's degree and fulfill requirements for teacher certification in Pennsylvania. Additionally, students who major in Materials Science & Engineering (B.S.) can also enter a fifth year program that will earn them teaching certifications in physics, mathematics, general science, and possibly chemistry. These students also earn a Master's degree (M.Ed.) in education at the completion of their fifth year.

P.C. Rossin College of Engineering and Applied Science

John Chen, dean
Philip A. Blythe, associate dean of graduate studies

The P.C. Rossin College of Engineering and Applied Science offers the master of science and doctor of philosophy degrees in each of its six academic departments and in interdisciplinary programs as well. The departments in the college are chemical engineering, civil and environmental engineering, electrical engineering and computer science, industrial and manufacturing systems engineering, materials science and engineering, and mechanical engineering and mechanics. In addition, a student may earn the master of engineering degree in chemical engineering, civil engineering, electrical engineering, industrial engineering, and materials science. A master of science degree is offered in computer engineering, quality engineering, and management science. Master of science, master of engineering and Ph.D. in environmental engineering are offered in the Department of Civil and Environmental Engineering. The latter two degrees are offered in the Industrial and Manufacturing Systems Engineering Department. Master of science and Ph.D. degrees in computational and engineering mechanics are offered in the Department of Mechanical Engineering and Mechanics. Each department creates its own course, examination, and thesis or dissertation requirements within the framework of those established by the university.

Graduate study in the College of Engineering and Applied Science is closely related to the college's extensive research activity, and graduate students are expected to engage in analytical or experimental research as part of their programs of study. This activity involves students in the process of creation of new knowledge under the direction of the college's distinguished faculty and brings them into contact with some of the most modern and advanced experimental techniques. Many college research programs are supported by contracts, fellowships, and grants from industry and from federal, state, and local governments. This funding not only provides financial support for outstanding students but also allows them to deal with some of the more complex and pressing problems facing our society now and in the 21st century.

Many faculty members and graduate students in the College of Engineering and Applied Science are associated with interdisciplinary research centers and institutes as well as with their own departments. The opportunity for interdisciplinary study allows them to cross departmental lines in specific technological areas and to work with faculty and graduate students from other departments. Centers and institutes currently carry on research in the areas of biotechnology, health sciences, thermofluids, materials, energy, environmental sciences, surfaces and coatings, solid-state studies, structural and geotechnical studies, high-rise habitats, emulsion polymers, fracture and solid mechanics, metal forming, robotics, computer-integrated manufacturing, and design and management innovation. Extensive research in many of these areas is also conducted with academic departments.

Admission to Graduate Study

A graduate of an accredited college or university may be considered for admission to graduate study. The decision to admit a student rests with the applicant's major department and stands for one year following the first semester for which admission was offered. If more than one year elapses, the prospective student's department reserves the right to reconsider the original offer. Students wishing to pursue the master's degree in manufacturing systems engineering should apply to the interdisciplinary program directly.

Applications for admission may be obtained by writing to the department to which admission is sought or to the office of the dean of one of the colleges.

An applicant may enter the graduate program as a student in the following categories: regular, associate, non-degree seeking, or graduate assistant. Except for qualified Lehigh undergraduates, only those who have been admitted officially by the graduate program office of an appropriate college or by a department in one of the categories above may register for graduate courses or take them for credit.

Regular graduate students. Only regular graduate students are candidates for graduate degrees. Application for admission as a regular graduate student must be filed by July 15 for the following fall semester or by Dec. 1 for the spring semester. Regular applications for the first and second summer sessions are accepted until April 30 and May 30, respectively. Certain departments or programs have earlier deadlines. Applicants should consult their respective departments or their dean's office. In order to be considered for admission as a regular graduate student, the applicant must satisfy at least one of the following conditions: have an undergraduate G.P.A. of at least 2.75 out of 4.00; have an average of at least 3.00 for the last two semesters of undergraduate study; have scores at or above the 75th percentile on the Graduate Record Examination or other recognized test (all foreign graduate students are required to take the Test of English as a Foreign Language and achieve a minimum score of 550); have a graduate grade-point average of at least 3.00 for a minimum of twelve credit hours of graduate work completed at other institutions; or have successfully satisfied the probationary conditions as an associate graduate student discussed below. Satisfying one of these conditions is a necessary but not sufficient condition for admission as a regular graduate student.

Individual departments may evaluate their candidates for admission according to higher standards and additional criteria.
Departments should be consulted for information regarding required examinations for admission. For example, candidates for the M.B.A. program are required to take the Graduate Management Admissions Test (GMAT).

Admission of a student to graduate standing is executed through the Office of Graduate Studies in each college or the respective dean's office. Credentials for admission to counseling psychology and school psychology programs and to the doctoral programs in special education are acted upon only once a year. Completed applications and requests for financial aid must be submitted by January 15 for admission in the following fall semester. Applications received for these programs after this deadline will be dealt with on a space-available basis.

**Associate Graduate Students.** Associate graduate student status may be offered to applicants who apply but fail to qualify for regular graduate student status. Only associate student applications will be considered during the late admissions period between the end of the regular admission period and the first day of classes. Applicants for associate status may submit unofficial rather than official transcripts; letters of recommendation are not required at that time. The Registrar will require an official final transcript, however, before grades are released. Certain departments or programs have earlier deadlines and more stringent requirements. Applicants should consult their respective departments.

Associate graduate students who are admitted during the late admission period and who clearly qualify for admission as regular graduate students may petition for regular status after classes begin if all credentials are in order. There is no late application fee. Individual departments may have more stringent requirements.

Other associate graduate students must meet the following condition before they may petition for regular status: completion of the first nine credit hours of courses numbered 300 or higher with at most one grade of C+ or below. Students receiving a grade lower than a C will be dropped from the program. Students should note that individual departments may impose more rigorous probationary standards.

When the probationary period of nine credit hours is completed successfully, associate graduate students must petition for regular student status in order to continue. This requires the submission of regular admission documents not on file. Courses completed during a successful probationary period may count toward a graduate degree if they are part of an approved program.

**Non-Degree-Seeking Students.** Students who do not wish to enter a degree program may seek admission with non-degree status. In this case, the prospective student completes an abbreviated application form (available from the appropriate college). The admissions criteria for non-degree graduate students are: 1) a bachelor's degree from an approved institution with an overall grade point average of at least 3.0; (applicants with undergraduate GPAs below 3.0 may be admitted with the approval of the department in which they wish to take courses); or 2) evidence that the applicant is presently a student in good standing in an appropriate graduate program at an approved institution; or 3) evidence that the applicant has received an appropriate graduate or other advanced degree from an approved institution. 4) International students are required to demonstrate English language skills equal to those required of degree-seeking students. All international applicants whose native language is not English must take the TOEFL (Test of English as a Foreign Language). A minimum score of 550 is required for admission. This TOEFL requirement may be waived if the international applicant has studied in an English-speaking university for at least one year.

Admission decisions for non-degree students are made by the dean of the appropriate college or other responsible official designated by him/her for this purpose. The signature of the designated official on the application and registration forms confers admission to the non-degree graduate student status. Informal transcript will be accepted for initial admission, but formal transcripts must be on record before the student can receive any transcript or grade report from the university or enroll for additional courses.

Non-degree students may take no more than twelve hours of graduate study at Lehigh. Any transcript or other record from the university will clearly indicate the student status as non-degree.

**Lehigh University Undergraduates.** A Lehigh undergraduate may take any 400-level course for which he or she is qualified. The qualifications are defined by the department, and are certified by the course instructor and department chairperson through petition to the graduate and research committee.

Undergraduates at Lehigh who are within a few hours of meeting the requirements for a baccalaureate degree may, with the special approval of the graduate and research committee, enroll for a limited amount of study for graduate credit. Lehigh undergraduates may apply course credits taken in the undergraduate program toward a graduate degree under the following conditions: (a) the course credits are not submitted as part of the requirement for an undergraduate degree; and (b) courses for possible graduate credit are approved in advance by the course instructor, department chairperson, and the dean of the college. The student must receive a grade of B- or better.

**Readmission.** A student who has not been registered in a Lehigh graduate program for five years must petition for readmission. Petitions approved by the student's major department must be forwarded to the registrar's office.

**International Students and Scholars.** International applicants must hold an American bachelor's degree or an equivalent foreign degree requiring at least 16 years of primary, secondary, and university education. International applicants must submit all documents required for regular graduate student status, as explained above. Brochures for international applicants may be requested from individual departments.

**Registration Requirements.** All graduate students using Lehigh University resources must be registered. No graduate student may register for more than 15 credits per semester. University employees may register for, at most, two courses per semester with appropriate approval. The maximum registration in a summer session is six credits.

**Full-Time Status.** In order to maintain full-time enrollment status, a graduate student must ordinarily register for a minimum of nine credits each semester. Identification as a full-time student is important for three purposes: (1) eligibility for financial aid, (2) compliance with visa requirements for international students, and (3) for university and national graduate enrollment data.

After fulfillment of degree credit-hour requirements and in some other circumstances, full-time status may be maintained with fewer than nine credits of registration, provided that the student is, in fact, continuing a program of full-time study and research. In such cases, the status must be certified on the Graduate Registration Form, first by the department and then by the appropriate college.

**Registration Procedure.** Pre-registration is scheduled for a two-week period at a time designated on the university calendar. Graduate registration is held during the week preceding the start of classes. Students should check with their departments for registration and semester class schedules. To register, graduate students must complete registration forms available in their departments. A course adviser will discuss course selections with students and sign registration forms upon approval.

**Late Registration Penalties.** Registration between the second and tenth day of class during the fall and spring semesters, and the second and fifth day of class during the summer sessions will
require a late registration fee. Students who have not completed the registration process by the tenth day of the regular academic semester or by the fifth day of the summer session will not be permitted to attend class.

Services provided by the registrar. In addition to maintaining student academic files, the office of the registrar fills transcript orders. The registrar honors written and over-the-counter requests to have transcripts mailed to schools and prospective employers.

The office also forwards final grades to students after each final exam period, provided student credentials are in order.

Graduate Credit and Grades

Course grades are defined as for undergraduates except that no grade lower than C may be counted toward a graduate degree and pass-fail registration is not allowed for graduate students.

No regularly admitted student who receives more than four grades below a B- in courses numbered 200 or higher is allowed to continue registration as a graduate student.

The N grade is defined as for undergraduates except that graduate students have a calendar year to remove course incomplete grades unless an earlier deadline is specified by the instructor. Graduate student incomplete course grades that are not removed remain as N grades on the student's record. Thesis or research project N grades may remain beyond one year until the work is completed.

The X grade is defined as for undergraduates except that to be eligible for a make-up examination a graduate student must file a petition and the petition must be approved by the graduate and research committee.

The XN grade is defined as for undergraduates except that graduate students have a calendar year to complete coursework following an XN grade unless an earlier completion deadline is specified by the instructor. The XN portion of the grade is removed as described for undergraduates. XN grades which are not removed remain on the record of graduate students. All petitions for exceptions are sent to the graduate and research committee.

Withdrawal From A Course. A student dropping a course within the first ten days of the semester (five days for summer sessions) will have no record of the course on the transcript. A student dropping all courses for which he or she is registered is considered to be withdrawing from the university and the policy is noted below. A student who drops a course after the tenth day of instruction and before the end of the eleventh week of instruction will have a grade of "W" assigned to the course. A student who drops a course after the eleventh week of instruction and before the end of classes receives a "WP" or "WF" at the discretion of the instructor. A "WF" is considered to be a failing grade. An Add/Drop form signed by the student's adviser must be submitted to the registrar's office before the deadlines noted to be official.

University Withdrawal. A student withdrawing from the university (dropping all courses during a given term) must submit the Drop/Add form signed by the adviser to the registrar's office. Withdrawal after registration day and during the first four weeks of instruction will be noted on the academic transcript by assigning a grade of "W" to all courses. A withdrawal after the fourth week of instruction and before the end of classes will have the grade of "WF" assigned for each course at the discretion of the instructor. The date of the withdrawal will be noted on the academic transcript for a withdrawal at any time during the term.

Graduate Student Scholastic Requirements. The guidelines state the requirements for all graduate students regardless of the degree sought.

Associate Students: will be placed on probation when they receive their first grade below a "B-" and will be dropped for poor scholarship at the end of a term when the student is assigned either a single grade below a "C-" ("C-" is considered a grade below a "C") or the second grade below a "B-".

If an associate student is assigned two grades below a "B-" in the same term the student is eligible to be dropped without any term on probation.

Once on probation students remain on probation until they are granted regular status or graduate. Students who are eligible to be granted regular status but fail to apply do so will be evaluated according to the above criteria.

Regular Students: will be placed on probation at the end of the term in which they are assigned their fourth grade below a "B-" in course numbered 200 or above;

will be dropped for poor scholarship at the end of any term in which they are assigned their fifth grade below a "B-".

Once regular students are placed on probation they will remain on probation until they receive their degrees.

Readmission: graduates students who have been dropped for poor scholarship are ineligible to enroll for the next regular term. After one term away they may petition for readmission. The department and the dean's office must approve the petition. The student will be readmitted on probation and may be dropped again with any additional grades below a "B-".

Graduation

Degree registration. A student must be registered in the semester in which the degree is conferred.

Application for degree. Candidates for degrees to be conferred on University Day in May or June must file an application for degree with the registrar by March 1. Candidates for degrees to be conferred in January must file by November 1. Late application for a degree will incur a penalty fee of $25.

Clearance. Graduate students must receive clearance from the university prior to the awarding of the degree. The following obligations must be satisfied:

• Students must complete all coursework for incomplete they have received.

• Theses and dissertations must be cleared by the appropriate dean's office.

• All financial obligations must be cleared with the bursar.

Tuition and Fees

Tuition payment. Graduate students must register for courses and pay tuition bills at the bursar's office during the registration period held the week before classes begin. Students who mail their registration forms, personal data sheets, and tuition payments to the bursar's office must be certain that their forms are postmarked two business days prior to the final day of the registration period.

Tuition refunds. A student in good standing who formally withdraws from a course during the first eight weeks of the semester is eligible for a tuition refund. The refund schedule for student withdrawals and course adjustments is as follows:

<table>
<thead>
<tr>
<th>If the withdrawal occurs</th>
<th>Refund</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st through 8th day of classes</td>
<td>90%</td>
</tr>
<tr>
<td>9th through 20th day of classes</td>
<td>50%</td>
</tr>
<tr>
<td>21st through 40th day of classes</td>
<td>25%</td>
</tr>
<tr>
<td>balance of semester</td>
<td>0%</td>
</tr>
</tbody>
</table>

Students should note that the first calendar week begins with the first day of classes at the university.
Tuition and Fees for 1999-2000

<table>
<thead>
<tr>
<th></th>
<th>per</th>
<th>credit hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>College of Arts &amp; Sciences</td>
<td>$860</td>
<td></td>
</tr>
<tr>
<td>College of Business &amp; Economics</td>
<td>$610</td>
<td></td>
</tr>
<tr>
<td>College of Education, and for full-time elementary and secondary teachers and administrators enrolled in the other three colleges</td>
<td>$470</td>
<td></td>
</tr>
<tr>
<td>College of Engineering &amp; Applied Science</td>
<td>$860</td>
<td></td>
</tr>
<tr>
<td>Per course charge for audit</td>
<td>same as a one-credit charge in the appropriate college</td>
<td></td>
</tr>
<tr>
<td>Maintenance of candidacy</td>
<td>same as a one-credit charge in the appropriate college</td>
<td></td>
</tr>
<tr>
<td>Master's candidate registration fee</td>
<td>same as a one-credit charge in the appropriate college</td>
<td></td>
</tr>
</tbody>
</table>

Living accommodations. The university maintains a graduate student housing complex in the Saucon Valley that has 136 living units. This complex, Saucon Village Apartments, provides units generally on a yearly lease basis. For the 1998-99 period beginning in September, the following are the monthly rents exclusive of utilities:

- Efficiency apartment: $385
- One-bedroom apartment: $450
- Small two-bedroom apartment: $485
- Two-bedroom apartment w/o AC: $500
- Two-bedroom apartment w/AC: $510
- Three-bedroom apartment: $520

Other Fees

- Application fee (for graduate admission consideration): $40
- Non-degree application (engineering, education): $20
- Graduate activities fee, per semester:
  - Full-time students: $12
  - Part-time students: $6
- Late registration: $50
- Late application for degree: $25
- Late payment (after announced date): $100
- Returned check fine: $20
- Identification card (replacement): $10
- Thesis, microfilming: $25
- Dissertations, microfilming: $50
- Supervision fee, College of Education (per 3 credits):
  - Counselor intern: $100
  - Counselor and school psychology clinic: $100
  - Social restoration intern: $225
  - Reading practicum: $100
  - Administrative intern: $225
  - Elementary and secondary intern: $225
  - Special education intern: $225

Financial Aid

Financial aid is ordinarily available only for regular, full-time graduate students. Teaching assistantships, research assistantships, graduate assistantships, fellowships, and scholarships are academic awards made by individual academic departments. Several graduate assistantships unrelated to a particular area of study can be obtained by applying to administrative offices. International students are also encouraged to apply for funding to outside sponsoring agencies and/or home governments. Finally, loans and work-study employment are distributed by the Office of Financial Aid.

Academic awards. Requests for fellowships, scholarships, research assistantships, teaching assistantships, and graduate assistantships to begin in the fall semester must be filed with academic departments no later than January 15. Generally, a special committee formed by department faculty selects the recipients of these awards based upon merit; students are not required to submit a financial statement.

In addition to their stipends, graduate students holding half-time teaching appointments generally receive tuition remission. Fellowship holders also receive a stipend and tuition award. Scholarship recipients are awarded tuition. Research assistants receive a stipend for research services, but their tuition is commonly paid directly by research projects.

Teaching assistants and graduate assistants. Teaching assistant and graduate assistant (TA/GA) are technical terms used to describe specific types of Lehigh University student employees. The duties of TAs and GAs are generally set by the departments or offices that employ them, but certain conditions must be satisfied before a student can be classified as a teaching assistant or a graduate assistant. These include:

- Each TA/GA must be a regular full-time resident Lehigh graduate student, which normally requires registration for at least nine credit hours per semester.
- A TA/GA is a half-time position and each TA/GA provides services to Lehigh University of up to twenty hours per week. Quarter-time and eighth-time TA/GA appointments are possible for full-time resident graduate students, with stipends and tuition remission appropriately reduced.
- Each TA/GA must be paid a specific stipend, which is set for the academic year by the dean of the appropriate college after consultation with the director of budget.
- Qualified TAs/GAs receive tuition remission for at most ten credit hours in a regular semester. No TA/GA may register for more than ten credit hours. A student who is a TA/GA during the preceding academic year is entitled to at most three hours of thesis, research, or dissertation registration (not course credit) in the following summer without payment of tuition.
- Each TA/GA is appointed by a process which begins with a formal letter of appointment issued by the appropriate department chairperson. The appointment letter specifies standard university conditions including stipend level, time of arrival, length of service, and the requirement of satisfactory academic progress and performance of duties. Each department chairperson submits written notification of TA/GA appointments to the appropriate college dean or vice president.

The graduate and research committee endorsed academic guidelines for new teaching assistants which exceed minimum admission requirements. Each TA should satisfy one of the following: have a G.P.A. of 3.0 or better in the undergraduate major field of study; have a G.P.A. of 3.5 in the senior year major field; rank in the 85th percentile or higher on the Graduate Record Exam or other standardized test; or have a G.P.A. of 3.5 in at least twelve hours of graduate work in the major field. Exceptions to these guidelines shall be made only with the approval of the appropriate dean.

In addition, each teaching assistant must make normal progress toward a graduate degree. The definition of normal progress may vary among departments, but the criteria for satisfactory progress are established by the department faculty and the graduate and research committee. Teaching assistants who fail to satisfy these criteria are ineligible for reappointment.

Teaching assistants whose native language is other than English must have on record with the ESL Program in addition to a minimum total score of 550, a comprehensibility score of 230 or higher on the SPEAK (Speaking Proficiency English Assessment Kit) or the TSE (Test of Spoken English) in order to work with Lehigh undergraduates in academic settings (i.e., classrooms, recitations, labs, office hours, etc.).

Those whose comprehensibility score is 220-229 may also be appointed as TAs, but they are required to attend ESL courses until their comprehensibility score is at least 230 or until they no longer have a TA position. A comprehensibility score of 200 or below eliminates an international graduate student from being appointed as a TA.
The SPEAK is given at announced times during the academic year, usually at the beginning and end of each semester. Contact the ESL Program (302 Coppee Hall, ex. 86099) for details and for information concerning ESL courses. The TSE is given by ETS several times each year throughout the world.

Tuition remission for qualified TAs/GAs is authorized by the appropriate dean or vice president as part of the registration process. Each college dean or appropriate vice president will be provided tuition remission accounts against which TA/GA remissions will be charged. The accounts will be budgeted at an amount equal to the ten-hour TA/GA tuition rate times the approved number of TA/GA positions included in the annual operating budget. The budgets shall not be exceeded. If additional TA/GA positions are desired on a temporary basis, the account executive must provide for the transfer of budget support to the remission account. These budgets are to be used exclusively for tuition remission for authorized TA/GA positions.

There are a limited number of summer TA/GA appointments. These TA/GA employees must receive the same monthly stipend as academic year TAs/GAs and provide services of up to twenty hours per week to the university. A summer TA/GA registers for a maximum of three credit hours in each summer session of employment and receives tuition remission for that registration.

Other graduate assistantships. Graduate students may apply directly to administrative offices for graduate assistantships unrelated to their areas of study. The availability of these assistantships is based upon the needs of the individual departments. GAs are employed regularly by the office of the vice provost for student affairs, the dean of students office, the university counseling service, and by career services.

Loans and work-study awards. Students may apply for the federally-funded Stafford and Perkins loans, Lehigh University Tuition Loans (ULT), and Federal Work-Study through the Office of Financial Aid at 218 W. Packer Avenue. These funds are awarded on the basis of demonstrated need using the Free Application for Federal Student Aid, the university application, and a copy of the most recent (1999) IRS 1040. It is also required to obtain information on all previously federal student loan borrowing from any other college(s) attended, as well as an indication that there is no prior default or refund due the government for overpayment of federal aid. Lehigh depends upon the information displayed on the Student Aid Report (SAR), obtained from the National Student Loan Data System after filing the FAFSA. If that doesn’t provide the necessary certification, have each college send Lehigh a Financial Aid Transcript. It is hoped the NSLDS will provide the necessary confirmation so that the transcript will not be necessary. Funds cannot be disbursed without a SAR (and the NSLDS information) or a FAT on file. This is a federal requirement. Students not able to demonstrate “need” may borrow from the Federal Unsubsidized Loan Program. Because the Stafford loans are financed through commercial lenders, their availability is virtually assured if students qualify. There is only limited availability of Federal Perkins and Work-Study, and University Tuition Loans.

Literature on federal student aid programs is available through the financial aid office. Particulars on the Federal Stafford Loan (with and without subsidy) are also available at participating lenders. A listing of student “rights and responsibilities” is printed in the section on undergraduate financial aid. The Office of Financial Aid can provide a list of preferred lenders and their availability is federally-funded Stafford and Perkins loans, Lehigh University Title IV Loans, and their applications for Federal Stafford Loans, as well as a listing of commercial educational loans together with current interest rates and terms and conditions of repayment.

Degree Information
The following degrees are offered by the university: the master’s degree, the doctor of philosophy, the doctor of education, and the doctor of arts.

Master’s Degree
Candidates for the master’s degree have six years in which to complete their programs. Students should confer with their advisers to be certain that specific department and program course requirements are met. The following requirements must be satisfied by master’s candidates in all departments.

Program for the master’s degree. A student’s program must include: not less than 30 credit hours of graduate work; not less than 18 credits of 400-level coursework (research or thesis registration counts as part of the 400-level coursework requirement); not less than 18 credits of coursework in the major of which 15 credits must be at the 400 level. All coursework for the master’s degree must be taken under at least two instructors and must be approved by Lehigh University. With the approval of the appropriate dean, a maximum of six credits may be transferred to a Lehigh master’s program. A petition is submitted, with course descriptions and transcript, as well as departmental recommendation. Course grades of B or better are required.

A student must complete the form, “Program for Master’s Degree,” setting forth the courses proposed to satisfy the degree requirements. This form should be approved by the department and then submitted to the registrar as soon as possible after 15 credit hours toward the degree have been completed. Approval of the program by the registrar signifies that the student has formally been admitted to candidacy for the master’s degree.

Thesis and comprehensive exam. Candidates are required to submit a thesis or a report based on a research course of at least three credit hours, or to pass a comprehensive examination given by the major department. The department will specify which of these requirements applies and may require both. If required, the thesis or report shall not count for more than six credit hours, and thesis registration is limited to a maximum of six credit hours. University procedures must be followed if the thesis or research project involves human subjects. One unbound copy of the thesis, approved by the thesis adviser and the appropriate dean, must be delivered to the registrar’s office at least three weeks before the degree is conferred. A binding and microfilming fee of $25 must be paid to the bursar, and the bursar’s receipt presented with the completed thesis. Guidelines stipulating the form of the thesis are available in the registrar’s office.

A non-thesis option exists for certain programs in the Colleges. Students should check with their departments regarding that option.

Doctor of Philosophy
Time and Registration requirements. A candidate for the doctor of philosophy degree ordinarily is expected to devote at least three academic years to graduate work. In no case is the degree awarded to someone who has spent less than two full academic years of graduate work. All post-baccalaureate work toward the doctorate must be completed within ten years. A student beginning doctoral coursework after an elapsed period of at least one semester after the master’s degree has been conferred is granted seven years in which to complete the doctoral program.

Doctoral students whose graduate study is carried out entirely at Lehigh University must register for a minimum of 72 credits beyond the Bachelor’s degree. However, resident students who during their entire doctoral program, including the semester of graduation, have paid full tuition continuously (normally a minimum of 9 credits per academic semester) will have satisfied the tuition requirements for the doctoral degree upon completion of all other requirements. Students who have earned a master’s degree at another university must register for a minimum of 48 credits. These requirements include registration for research or dissertation credits.

Full-time students working toward the doctorate normally register for a minimum of nine credits each semester. If the
Since these examinations vary among departments, students scheduled. After completion of the minimum registration requirement plus any additional requirements of the student's department or program, registration is permitted for 'Maintenance of Candidacy.' The tuition charge is for one credit-hour. Full-time status again must be certified on the graduate registration form.

Residence. Each Ph.D. candidate must satisfy Lehigh's residence requirement. The residence requirement is intended to ensure that doctoral students spend a period of concentrated study and intellectual association with other scholars. Either two semesters of full-time graduate study or 18 credit hours of graduate study within a twelve-month period must be completed.

Individual departments may impose additional stipulations. Candidates should check with their advisers to be certain that they have satisfied their residence requirements.

Language requirements. Language requirements for the Ph.D. are the option of and in the jurisdiction of the candidate's department. Since proficiency in a language is not a university requirement, each department decides which languages, if any, constitute part of the doctoral program.

Qualifiers. Many departments require students who wish to enroll in doctoral programs to pass qualifying examinations. Since these examinations vary among departments, students should ask their advisers or department chairpersons for more detailed information. If a qualifying examination is not used, students should find out how and when eligibility to pursue doctoral studies is determined.

Admission to candidacy. With the help of an academic adviser, the student names the faculty members of the doctoral committee, a special committee formed to guide the student through the doctoral program. The committee is responsible for assisting the student in formulating a course of study, satisfying specific departmental requirements, submitting a suitable dissertation proposal, overseeing progress in research, and evaluating the completed dissertation. At least four faculty are appointed to the committee; one must be a member of an outside department. Committee membership must be approved by the university's graduate and research committee.

A doctoral student should apply for candidacy no later than one year after completion of the master's degree or its equivalent and after passing qualifying examinations if they are required by the major department. The prospective Ph.D. candidate must submit to the doctoral committee a written program proposal that includes a discussion of proposed dissertation research. Upon receiving approval of the proposal, the candidate submits the proposal, signed by the committee members, to the appropriate dean for action by the graduate and research committee. The dean will advise the student of the committee's decision.

If the dissertation research involves human subjects, university procedures must be followed.

General examinations. Examinations composed and administered by the members of the student's doctoral committee are designed to test the candidate's proficiency in a particular field of study. These examinations, which may be both written and oral, should be passed at least seven months before the degree is to be conferred. If a student fails the general examination, a second examination will be scheduled not earlier than five months after the first. If the results of the second examination are unsatisfactory, no additional examination is scheduled.

Dissertation and defense. The Ph.D. candidate is required to write a dissertation prepared under the direction of a Lehigh University professor. The dissertation must treat a topic related to the candidate's specialty in the major subject, show the results of original research, provide evidence of high scholarship, and make a significant contribution to knowledge in the field.

Upon approval of the advising professor and, if required by the department, secondary readers, the dissertation is submitted to the appropriate dean for inspection at least six weeks before the degree is to be conferred. Upon its return, the student should distribute copies of the draft to the members of the doctoral committee for review and for suggestions for revision. The candidate then schedules a dissertation defense before the doctoral committee, additional faculty members the department may add to the examining committee, and the general public.

After the dissertation has been defended and revised accordingly, the student must submit the finished dissertation to the appropriate dean for review by the university's graduate and research committee. The dissertation is submitted no later than two weeks before the degree is to be conferred. One unbound copy must be delivered to the dean's office. It must bear the original signatures of the special committee members. In addition, the candidate must pay a microfilming fee of $50 and present a bursar's receipt for the payment. Guidelines stipulating the standard form of the dissertation are available in the dean's office.

Doctor of Arts (D.A.)
The doctor of arts degree (D.A.) is offered to students preparing for careers in college teaching in the field of chemistry. The program requirements are similar to those for the Ph.D. with the following exceptions: (1) a broader distribution of graduate courses in the field, (2) a minor area of study for students interested in bidisciplinary preparation for two-year college teaching, (3) coursework and training in interpersonal awareness, (4) a supervised internship in college teaching, and (5) a research project appropriate to college teaching in the student's field of specialization.

Graduate Degrees in Business Administration and Economics
Candidates for admission to graduate study in the College of Business and Economics must provide the results obtained in either the Graduate Management Admissions Test (GMAT) for degrees in business administration, or the Graduate Record Examination general test (GRE) and the subject test in economics for degrees in economics. Either may be submitted for the M.S. in Management of Technology.

Master of Business Administration
The Lehigh MBA provides a rich, integrated learning experience for students. Business issues are viewed and taught from the perspective of the firm as a whole rather than along departmental lines. Lehigh's MBA curriculum is a fully interdisciplinary and taught by an eight-member faculty team.

Teams, comprised of students from each of the core courses, are assigned a comprehensive case during their first year in the program. These teams closely resemble interdisciplinary corporate teams where each person has a different and valuable set of knowledge, skills and experience.

The core capstone experience provides alternative methods for students to apply the body of knowledge acquired in the core. Students will be encouraged to design industry projects within their own firms or with a corporate partner. Lehigh's faculty will work with the student and a supervisor at the firm to select a project and explore a new or existing business opportunity. This will provide added exposure for the student within their own firm, possibly in a business area outside of their current position which is of interest to them.
Full-time students may choose an internship or other suitable experiential learning. The academic rigor and time required to complete the project will determine the credit hours assigned to the project.

Due to the compact and integrated core, students have increased flexibility to tailor the program to their individual needs. Students may select a concentration in finance, management, marketing, international business or management of technology or pursue a broader experience by selecting courses from a variety of disciplines.

Effective oral and written communication skills and leadership ability have become increasingly important keys to success in business. Using case studies, group projects and a team approach to learning, Lehigh's curriculum helps students experience the dynamics of group behavior within organizations and methods used to motivate workers and resolve conflicts. Specialized courses in leadership and areas such as managing diversity, are among the program's most popular courses.

**MBA Mission Statement.** To develop the knowledge, skills and abilities of managers through a comprehensive and integrated core curriculum with customized concentrated learning designed to meet the individual needs of students.

**Innovative Structure.** The MBA Program requires 36 credit hours. Full-time students can fulfill that requirement in 12 to 15 months. Most part-time students require three years. Students may select a concentration in finance, management, marketing, international business, or management of technology or pursue a broader experience by selecting courses from a variety of disciplines.

**Prerequisites.** Students should have completed undergraduate courses in computer literacy, principles of microeconomics and macroeconomics, financial accounting and statistics before entering the MBA program.

The prerequisites of financial accounting and statistics may be fulfilled by taking a class within the past 5 years and receiving a "B" or better, or by taking a proficiency exam. In order to assist students preparing to take the proficiency exam, a packet of self-directed learning materials will be available.

If a student has no previous background in financial accounting or statistics, he or she is encouraged to take a course in the subject area. If a student has previously taken coursework but has not achieved a grade of "B" or the course has exceeded the time limit, self-directed learning and a proficiency exam may be appropriate.

The prerequisites of financial accounting and statistics must be completed before enrolling in MBA 402 or MBA 403.

**Core Courses.**
- MBA 401, Introduction to the Organization and Its Environment (1)
- MBA 402, Managing Financial and Physical Resources (4)
- Prerequisite: Financial Accounting
- MBA 403, Managing Information (4)
- Prerequisites: Financial Accounting and Statistics
- MBA 404, Managing Products and Services (4)
- MBA 405, Managing People (4)
- MBA 406, Integrative Experience (1-4)

**Electives.** Students will take 15 to 18 credits in electives depending on the credits earned for their integrative experience in MBA 406. Students may design a concentration to best suit their career goals. Nine credit hours of approved electives are required for a concentration in finance, management and marketing. Concentrations in international business and management of technology require twelve credit hours of approved electives.

To increase flexibility, students may also take up to six credit hours of electives outside of the College of Business and Economics (but within Lehigh University). All elective courses must be at the 400 level.

**Waiver Policy.** There are no waivers for courses in the MBA Program.

**GMAT Scores.** All applicants are required to take the Graduate Management Admissions Test (GMAT) administered by the Educational Testing Service (ETS). The computer-based exam is given during several weeks each month. Exams are administered through the local Sylvan Learning Centers. To make an appointment to take the GMAT exam call 1-800-GMAT NOW. GMAT applications can be obtained by writing to the Educational Testing Service, P.O. Box 6103, Princeton, NJ 08541-6103.

Students taking the GMAT in the United States, must submit the application and fee to ETS at least four weeks before the testing date. If taking the test elsewhere, submit the materials at least six weeks in advance. After the test, the results will be sent to the student and to the institutions designated within four weeks.

**Work Experience.** Students are required to have 2 years full-time, professional work experience.

**International Students/TOEFL.** International students must have 16 years of formal education, including four years at the university level, to be considered for admission to Lehigh's graduate programs. Applicants whose native language is not English are required to take the Test of English as a Foreign Language (TOEFL). For information on the TOEFL Registration Office, P.O. Box 6154, Princeton, N.J., 08541-6154.

**Flexible Class Scheduling.** Most classes are scheduled Monday through Thursday in late afternoons and evenings. Some courses are available on Saturday mornings. Part-time students may complete the entire program during evenings and Saturdays. Many students accelerate completion of the program by taking courses during the two six-week summer sessions.

Two-day seminars provide the opportunity to explore a single topic in depth. Organizational learning, business ethics, brand management, horizontal teams, the role of the board of directors, activity-based management, TQM, supply-chain management and managing change are examples of some seminars. Each seminar counts as one credit of elective work.

**Student Profile.** MBA students average eight years of professional work experience. Approximately sixty percent of the students have undergraduate degrees in engineering or science and over thirty percent have undergraduate degrees in business. The combination of work experience and diversity of background brings valuable professional perspectives to classroom discussions.

The average GPA for undergraduate work is 3.2 and over 20% of the students have graduate degrees in disciplines outside of business. The average GMAT score is 590 and average TOEFL scores exceed 600 for international students.

There are approximately 300 part-time students and 60 full-time students currently in the MBA Program. Over 100 of the part-time students take some or all classes by distance learning.

An MBA Program brochure and application for admission may be obtained by contacting Kathleen A. Trexler, Associate Dean and Director - MBA Program, Lehigh University, College of Business and Economics, 621 Taylor Street, Bethlehem, PA 18015. Prospective students may call (610) 758-4450 or send email to mba@lehigh.edu for additional information.

**Master of Science in Business and Economics**

The Master of Science program in Economics is available for students wishing to pursue graduate study in the areas of economics or economics and business. The program offers considerable flexibility with respect to the selection of courses as well as the ability to concentrate in a particular area of study. Students may pursue the degree on either a full-time or part-time basis. Recent graduates of the M.S. program have accepted employment with such firms as Andersen Consulting, AT&T, Pennsylvania Power and Light, and with the Federal Reserve System. Other students have pursued the master's degree as a stepping stone to the Ph.D. degree.

A minimum of 30 semester hours of course work is required. As part of the 30 hours, the following courses must be taken:
The Ph.D. degree in business and economics is designed to provide advanced knowledge and the capacity to carry on independent research in various areas of business and economics. Holders of the Ph.D. are normally employed in academic positions in departments of economics or in schools of business administration, or in policy analysis and research positions in banks, business, government, and research organizations. Employment opportunities are excellent for holders of this degree.

The Ph.D. program requires a minimum of 48 semester hours of study (including dissertation) beyond the master's degree or 72 hours of study beyond the bachelor's degree. Each student is expected to choose three major fields of specialization. Each student must take the eight core courses in economic theory, international economics, labor economics, managerial economics, money and banking, and public finance.

Under the guidance of a dissertation chairperson and committee formed after passing of the examinations, the candidate undertakes research culminating in an acceptable dissertation. The Ph.D. is awarded upon the successful completion of the doctoral dissertation and its oral defense.

For additional information or an application packet, please contact Dr. James Dearden, Adviser, Ph.D. program, College of Business and Economics, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015 or call (610) 758-4450.

**Graduate Degrees in Education**

Lehigh's College of Education offers only graduate degree programs. Students enrolled in the College of Education should check with their advisers for a list of regulations and requirements governing degree programs.

**Financial assistance.** The College of Education, because it does not offer many undergraduate courses, cannot usually provide teaching assistantships for graduate students. Graduate assistantships and research assistantships are available in the college and in various administrative offices on campus. In addition, graduate students may be recommended for a limited number of fellowships and scholarships, which are awarded by the college.

Lehigh's Centennial School, a laboratory school for socially and emotionally disturbed children, provides employment for some Lehigh education students. Graduate students may apply for teaching internships, which pay tuition plus salaries.

**Master of Education (M.Ed.)**

This degree is offered in the following professional specializations: elementary education, secondary education, special education, educational leadership, counseling and human services, and elementary and secondary school counseling. Degree requirements vary from program to program.

**Master of Arts (M.A.)**

The master of arts degree offered in the field of secondary education provides a major in education with an academic specialty. The student must take 18 credits of graduate work in education plus 12 credits of graduate work in an academic field. The academic fields that cooperate with the College of Education in offering this program include: modern languages and literature, English, mathematics, political science, sociology, and physical and natural sciences.

**Master of Science (M.S.)**

The master of science degree is awarded in educational technology.

**Educational Specialist (Ed.S.)**

Specialized post-master’s degree programs for practitioners are available in school psychology and special education.

**Certification and Concentration Programs**

In addition to offering master's degrees, the college offers state certifications in various professional specialties. The College of Education also offers special 12 to 15 credit programs that provide concentrations in gifted education and education of the severely/multiply handicapped.

**Doctor of Education (Ed.D.)**

The doctor of education degree program provides specialized study in elementary education, special education, educational leadership, curriculum and instruction, and educational technology. Successful professional experience is required for admission to candidacy for this degree in most programs.

The requirements for the Ed.D. degree parallel those already stated for the Ph.D. degree with the following exceptions: language examinations are not required and a statistics competency examination is required. The residence requirement for the Ed.D. is the same as that for the Ph.D.
Doctor of Philosophy (Ph.D.)
The College of Education also offers the Ph.D. degree to students enrolled in the fields of school psychology, special education, and counseling psychology. The requirements for this degree are the same as those for the Ph.D. in the other colleges and as described in previous sections.

Graduate Studies Organizations

The Graduate and Research Committee
The graduate and research committee consists of twelve members representing the faculties of Lehigh's colleges: four from the College of Arts and Sciences; two from the College of Business and Economics; four from the College of Education and Applied Science; and two from the College of Education; plus the college deans, the registrar, the director of the office of research, and two non-voting graduate student members.

The committee formulates policies and regulations on graduate education, and it recommends policies and procedures for research-related activities. The committee interprets and applies faculty rules governing graduate students and degrees, including questions concerning student petitions and appeals.

Graduate Alumni Committee
The Lehigh University Alumni Association has established a graduate alumni committee. The committee is composed of distinguished Lehigh graduate alumni and is chaired by Mary Comfort, Ph.D. ’95. The committee will provide leadership in deepening the involvement of graduate alumni in Lehigh affairs.

Graduate Student Council
The graduate student council, comprised of one graduate student from each academic department, represents the graduate student community regarding graduate programs and graduate student life at Lehigh. It provides a forum for discussion with university officials and committees. Graduate students selected by the graduate student council are non-voting members of the graduate and research committee and the educational policy committee.

Besides functioning as a forum for discussion, the graduate student council maintains a graduate student center. The council plans social events and disseminates information in order to facilitate communication among graduate students.

Interdisciplinary Graduate Study and Research

In addition to offering graduate degrees within academic departments, Lehigh University offers interdisciplinary graduate degrees in the fields of American Studies, clinical chemistry, manufacturing systems engineering, molecular bioscience and biotechnology, pharmaceutical chemistry, and polymer science and engineering.

In addition, Lehigh's interdisciplinary research centers and institutes address the research needs of government, industry, and society. Organized to recognize research efforts in interdisciplinary problem areas, they supplement the university's academic departments. Graduate students pursuing M.S. and Ph.D. degrees in academic departments as well as students enrolled in interdisciplinary degree programs may pursue research opportunities in the various centers.

A complete listing of research centers, institutes, and other research organizations appears following the section on interdisciplinary graduate programs.

Financial assistance. Teaching assistantships and fellowships are provided by individual academic departments, while research assistantships are available through both academic departments and research centers. Students interested in research are encouraged to seek appointments with members of the faculty working in their areas of special interest, with department chairpersons, or with center or institute directors.

Interdisciplinary Graduate Programs
Several interdisciplinary programs are offered to the Lehigh graduate student.

American Studies
A Master of Arts degree in American Studies is offered jointly by the departments of English and history. Candidates for the master's degree must complete at least 30 credit hours. In addition to the Theory and Method course, students must choose two courses in American history and two courses in American literature and film from those offered by the history department and the English department. Students must also take one special topics seminar. The other four courses for the master's degree will be divided between thesis or "thesis paper" credits and American Studies courses not in history or literature/film. To fulfill the thesis requirement, students will write one longer thesis or two thesis papers that are aimed at conference presentation and/or publication. For information, contact John Pettigrew, Department of History, College of Arts & Sciences, Lehigh University, 9 West Packer Avenue, Bethlehem, PA 18015. Phone: (610) 758-3355.

Clinical Chemistry
The M.S. program in clinical chemistry is offered by the Department of Chemistry in cooperation with local hospitals. It is directed toward training clinical laboratory scientists to be active in hospital-based and industrial laboratories in both patient sample service and new product development. The program requires fulfillment of a clinical laboratory practicum as well as a research project at the M.S. level. The core requirements for the degree are:

- Chm 371 Elements of Biochemistry I (3)
- Chm 372 Elements of Biochemistry II (3)
- Chm 332 Analytical Chemistry (3)
- Chm 336 Clinical Chemistry (3)
- Chm 358 Advanced Organic Chemistry (3)
- Chm 437 Pathophysiological Chemistry (3)
- Chm 421 Chemistry Research (1-4)

Clinical Laboratory Practicum

Electives or courses that may be substituted, upon an approved petition, for core requirements in clinical chemistry can be drawn from those listed in the Ph.D. programs in molecular biology or pharmaceutical chemistry (see below). Students may be admitted into this program from undergraduate majors in chemistry, biology, medical technology, or other areas of the biochemical life sciences. One semester of undergraduate physical chemistry is required for the M.S. in clinical chemistry although in some cases this course may be taken while enrolled as a graduate student but for no graduate credit. Graduates of the program are encouraged to continue their education toward the doctorate in any one of the several biological chemistry programs offered at Lehigh.

Management of Technology
Lehigh's Master of Science Program in Management of Technology (M.S. in MoT) is designed to prepare students to deal with the full range of functional and general management issues in technology-driven firms and industries.

The program prepares students with a firm knowledge base to analyze issues, formulate options and implement solutions in the areas of: creating, acquiring, commercializing and implementing technology; formulating and implementing strategy to achieve competitive advantage; interacting effectively with senior management; managing cross-functional teams involving engineers, scientists, financial managers, cost
Applicants must submit a completed application, including data sheet, official transcripts from all undergraduate and graduate institutions, two letters of recommendation, a personal essay and test scores from the Graduate Record Exam (GRE) or the Graduate Management Admissions Test (GMAT). Completed applications must be received by July 15 to be considered for the fall semester.

For further information, please contact: Center for Innovation Management Studies, Management of Technology Program, College of Business and Economics, Lehigh University, Rauch Business Center, 621 Taylor Street, Bethlehem, PA 18015-3117.
Phone (610) 758-6740; fax (610) 758-3655; e-mail: inmot@lehigh.edu

Center for Innovation Management Studies

The M.S. in MoT program is affiliated with Lehigh's Center for Innovation Management Studies (CIMS), a National Science Foundation-supported industry/university cooperative research center for the study of technological innovation and its management. CIMS is the hub of a national network of industrial corporate sponsors and academic research associates. The MoT program will draw upon this network of industrial, government and academic colleagues for guest lecturers and seminar speakers throughout the program.

Manufacturing Systems Engineering

Lehigh's award-winning graduate program leading to the master of science degree in manufacturing systems engineering (MSE) is sponsored by all the departments in the P.C. Rossin College of Engineering and Applied Science and is administered by the Center for Manufacturing Systems Engineering. In addition, the College of Business and Economics participates in teaching accounting, business, finance, management and marketing aspects of manufacturing systems.

This graduate curriculum aims to develop engineers who can design, develop, install, operate, and modify manufacturing systems involving materials, processes, equipment, facilities, logistics and people, with leading edge technologies. It integrates systems perspectives with interdisciplinary course offerings.

The 30-credit hour curriculum, may be structured as a one-year full-time program, beginning in January (some industrial experience is required), or a two-year part-time program for working engineers within commuting distance of campus. Courses in this flex-time program are scheduled on Thursday evenings and all-day Friday, in the spring and fall semesters. The core programs are structured as follows:

**FULL-TIME OPTION**

**Spring semester**

MSE 421 Technology, Manufacturing & Competitive Strategy (3)
MSE 423 Product Design/Analysis (3)
MSE 427 Production Systems (3)
+ one or two electives

**Summer session (ten weeks)**

One week-long study tour of industry visits selected manufacturing plants, design centers and research facilities. Students and faculty analyze the manufacturing strategies, systems and technologies used in these facilities.

The summer also provides opportunities for meeting elective requirements and completion of thesis/project research.

MSE students are required to pursue a three-credit project or six-credit thesis to complete the Master's degree:
MSE 451. Manufacturing Systems Engineering Project (3) OR
MSE 490. Manufacturing Systems Engineering Thesis (6)
An in-depth study of a problem in the area of manufacturing systems engineering. The study should lead to specific conclusions embodied in a written report, suitable for publication.

**Fall semester**

Required courses:
MSE 425 Production Planning and Resource Allocation (3)
MSE 431 Marketing & the Invention to Innovation Process
PART-TIME OPTION

First Spring semester (odd years)
MSE 421 Technology, Manufacturing & Competitive Strategy (3)
MSE 423 Product Design / Analysis (3)

First Fall semester
MSE 425 Production Planning & Resource Allocation (3)
Elective Course

Second Spring semester
MSE 427 Production Systems (3)
Elective Course

Second Fall semester (even years)
MSE 431 Marketing & the Invention to Innovation Process (3)
MSE 433 Technology and the Factory of the Future (3)

Summer sessions
Elective courses, thesis / project registration and research, and summer study tour are done during the summer sessions.

Additional Requirements.
All students must register for MSE 429 Special Activities (0) and pay a one time MSE Special Activities fee (3/2500 in 1999). There are weekly seminars, specially designed tutorials, visits to local manufacturing facilities, a week-long summer industry study tour, and meetings with executives from industry at which attendance is expected.

Elective courses (6 or 9 credit hours): In order to complete the 30 credit hour minimum, students are required to take three approved elective courses unless they register for a thesis (6 credit hours), in which case they are required to take only two elective courses.
Elective courses should be selected, in consultation with the MSE academic adviser and faculty, from the five technical and business areas related to manufacturing systems engineering. These areas include:
- design
- materials, processes and quality control
- automation, control systems, and computer integration
- computer and information systems
- business, management, organization and operations research

In addition to the regular classroom work, this program includes extensive use of Lehigh’s computing and engineering laboratories. There is heavy emphasis on the ability to communicate and work in teams.

Admission
A bachelor’s degree in engineering or in an appropriate science is required.
- Candidates enroll in the program through one of the university’s engineering departments, depending on individual backgrounds and interests.
- All candidates must follow admission procedures and standards established by Lehigh University.

Financial aid. A limited number of graduate fellowships are available on a highly competitive basis for MSE applicants.

Special Activities Fee. In addition to the applicable Lehigh University tuition, the MSE Program requires a special activities fee ($2,500 in 1999). Tuition and fees are expected to increase on a yearly basis.

Inquiries. For a brochure describing the MSE program, an application for admission (which includes an application for financial aid), or any additional information, please contact: Jeannette MacDonald, MSE Program Coordinator, H.S. Mohler Lab, 200 West Packer Avenue, Bethlehem, PA 18015 (610) 758-4667, FAX (610) 758-6527, Email jim1@Lehigh.edu or visit our website at www.lehigh.edu/~inmase/gradprogram/

Molecular Biosciences and Biotechnology
This interdisciplinary program leads to the degree of Master of Science in Molecular Biosciences and Biotechnology. The program is designed as a broad-based introduction to advanced study in the fundamental bioscience and engineering that is the foundation of modern biotechnology. Students are enrolled through the departments of biological sciences, chemistry, or chemical engineering and take a core set of courses in molecular biology, biochemistry, and biochemical engineering, supplemented with advanced level courses in these three areas. Full-time registrants conduct research under the direction of faculty members of these research areas. Students wishing to continue beyond the M.S. degree can enter Ph.D. programs in molecular biology, biochemistry, or chemical engineering.

The degree requires completion of 30 credits, 18 of which must be at the 400 level. The required core courses, representing 18 of the 30 credits, are:
- BioS 371 Elements of Biochemistry I (3)
- BioS 372 Elements of Biochemistry II (3)
- ChE 341 Biotechnology I (3)
- ChE 342 Biotechnology II (3)
- BioS 345 Molecular Genetics (3)
- BioS 411 Cell Biology (3)

With the consent of the M.S. program coordinator, students may petition for substitution of courses equivalent to the core courses. The substitutions must receive the approval of the department responsible for the course.

With the guidance of the student’s advisor and the M.S. program coordinator, the remaining 12 credits must be drawn from the following approved 400 level courses:
- BioS 415; BioS 405; BioS 421; BioS 422;
- ChE 444; ChE 445; ChE 450; Chm 423; Chm 424; Chm 437;
- Chm 450; BioS 467; BioS 468; BioS 469; BioS 470; BioS 471;
- BioS 472; Chm 473;

no more than six credits from the following 400-level approved lab courses:
- BioS 463; BioS 464; ChE 446; BioS 479; Chm 480

no more than six credits from the following 400-level approved seminar courses:
- BioS 406; BioS 466; ChE 448; Chm 435; Chm 477
- a minimum of three credits of the following:
- BioS 407; ChE 480; ChE 481; Chm 421.

All students must (a) register for six credits of research, successfully complete a research project under the direction of a faculty member in one of these areas, and submit a written report that is approved by the research advisor, the admitting department, and the M.S. program coordinator or (b) complete 6 credits of advanced level course work approved by the M.S. program coordinator and pass a comprehensive examination administered by the faculty from the program.

For further information, contact Neal Simon, Chair of the Department of Biological Sciences, Jacobus Hall, 111 Research Dr., Lehigh University, Bethlehem, PA 18015.

Pharmaceutical Chemistry
The graduate program in pharmaceutical chemistry leads to the M.S. and Ph.D. degrees. This curriculum prepares individuals who want to pursue careers in biomedical research, teaching, or administration, or in some aspect of public health.

Individuals may elect to specialize in one of the following areas: medicinal chemistry, drug development, diagnostic technologies, pharmaceutical spectroscopy, analytical methodologies, process chemistry, metabolism mechanisms, and molecular biological approaches to selected topics in pharmaceutical chemistry. The core course distribution and selection of electives may be altered to reflect the area of specialization.
Core Courses

Students select at least six of the following core courses:

- Chm 336  Clinical Chemistry (3)
- Chm 371/372  Elements of Biochemistry I and II (3 each)
- Chm 423  Bio-organic Chemistry (3)
- Chm 424  Medicinal and Pharmaceutical Chemistry (3)
- Chm 435  Advanced Topics in Clinical Chemistry (3)
- Chm 437  Pathophysiologial Chemistry (3)
- Chm 456  Spectral Analysis (3)
- Chm 477  Topics in Biochemistry (1-3)
- Chm 479  Biochemical Techniques (3)
- BioS 421  Molecular Cell Biology I (3)
- BioS 422  Molecular Cell Biology II (3)

Students enter through the departments and must meet each entering department’s criteria. When the student is ready (must have taken/be taking at least one polymer course and be in good standing in the department), the student petitions to transfer to the Center for Polymer Science and Engineering. After entering the center degree program, his/her degree program becomes Polymer Science and Engineering, but the student remains in the home department.

M.S. in Polymer Science and Engineering. For the M.S., the student's program must include: not less than 30 credits of graduate work; not less than 18 credits of 400-level course work, and not less than 18 credits of course work in the major, of which 15 must be at the 400-level. The program must include six course credits in the student's major field, six research credits, and a research report or thesis to the satisfaction of the faculty advisor, to be filed with the Polymer Education Committee.

Required courses:

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<tr>
<td>ChE (Chm/Mat) 388 Synthesis and Characterization Lab (3)</td>
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<tr>
<td>ChE (Chm/Mat) 393; Physical Polymer Science (3)</td>
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<tr>
<td>ChE (Chm) 394 Organic Polymer Science (3)</td>
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<td>Research (6)</td>
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<td>Three 400-level polymer courses to be selected from the following list (list may vary slightly from year to year):</td>
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<td>ChE 428 Rheology (3)</td>
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<td>Phy 472 Polymer Physics (3)</td>
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<td>ChE (Chm) 483 Emulsion Polymer (3)</td>
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<td>ChE (Chm/Mat) 482 Engineering Behavior of Polymers (3)</td>
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<td>ChE (Chm/Mat) 485 Polymer Blends and Composites (3)</td>
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<td>ChE 486 Polymer Processing (3)</td>
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<tr>
<td>Chm 489 Organic Polymer Science II (3)</td>
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<tr>
<td>Chm 491 Physical Chemistry of Organic Polymer Coatings (3)</td>
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<tr>
<td>ChE (Chm) 492 Topics in Polymer Science (3)</td>
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<tr>
<td>Chm 493 Organic Chemistry of Organic Polymer Coatings (3)</td>
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<td>ChE 487 Polymer Interfaces (3)</td>
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Courses in the admitting department must include one of the following:

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<tr>
<td>ChE (Chm) 400 Chemical Engineering Thermodynamics (3)</td>
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<td>Chm (ChE) 445 Elements of Physical Chemistry (4)</td>
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<td>Mat 401 Thermodynamics and Kinetics I (3)</td>
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<td>ME 420 Advanced Thermodynamics</td>
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<tr>
<td>Phy 442 Statistical Mechanics</td>
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<td>plus one other 300- or 400-level non-polymer related course from the admitting department.</td>
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M.E. in Polymer Science and Engineering. The M.E. degree requires the same course work structure as the M.S. degree above, however, instead of six hours of research credits leading to a thesis or research report, the student would take six hours of course work. The additional six hours of coursework must include two additional 300 or 400 level polymer courses, or one polymer and one non-polymer home department course. For full-time graduate students electing the M.E. degree option, the polymer course program must include Chem. Eng. (Chm; Mat) 388, Polymer Synthesis and Characterization, a laboratory course.

Part-time and Distance Education M.S. and M.E. degree students in Polymer Science and Engineering may substitute another polymer course for Chem. Eng. (Chm; Mat) 388.

Ph.D. in Polymer Science and Engineering. For the Ph.D., the student must satisfactorily complete a qualifying examination administered by the Polymer Education Committee; satisfactorily complete the handwritten degree course work determined in consultation with the doctoral committee; pass a general examination administered by the Polymer Education Committee; and defend the satisfaction of the doctoral committee, a dissertation in the field of polymer science and...
engineering. Students deficient in polymer science or related topics may be required by their committee to take remedial course work.

The doctoral committee consists of the research adviser, at least two other members of the center for polymer science and engineering, and at least one outside person. The committee's composition is subject to approval by the Polymer Education Committee and the graduate and research committee of the university.

For more information, write to Dr. M.S. El-Aasser, Director, Center for Polymer Science and Engineering, Iacocca Hall, Mountaintop Campus, Lehigh University, Bethlehem, PA 18015, or Dr. L.H. Sperling, Chairman, Polymer Education Committee, Whitaker Laboratory, Lehigh University, 5 E. Packer Avenue, Bethlehem, PA 18015. Please address applications to one of the participating departments.

Research Centers and Institutes

Lehigh has developed a number of centers and institutes to provide greater research and academic opportunities for primarily graduate students and faculty. Centers and institutes are generally interdisciplinary and complement the scholarly activities of academic departments and represent scholarship and research based on the expertise and capabilities of a group of faculty members. Frequently, centers relate to the broad-based research needs of government, industry, and the social community.

Biopharmaceutical Technology Institute

The Biopharmaceutical Technology Institute coordinates the education and research activity in the biopharmaceutical area of the chemistry and chemical engineering departments at Lehigh University. The main focus of this institute is to contribute to the creation and dissemination of engineering and scientific knowledge required to develop, improve, and regulate biotechnology and pharmaceutical industry processes and products.

Research activities. The research program of this institute is devoted specifically to the engineering and scientific fundamentals related to development, design, validation, CGMP (current Good Manufacure Practice) operation, safety, monitoring and control of fermentation, purification, product modification and formulation.

The research thrusts of the institute include: immunochemistry applied to clinical diagnostics; modification and use of monoclonal antibodies in radioidiosensitization and NMR imaging; structural analysis of glycoprotein pharmaceuticals; tumor image enhancement; medicinal chemistry; chemistry of biologically potent molecules; fundamental kinetics of microbial, mammalian and plant cell and enzyme systems; design and scale-up of bioreactor and bioseparation systems; development of instrumentation for the on-line monitoring of biological unit operations; development of novel separation and purification schemes for recovery of biologically active macromolecules, antigens, and antibodies; development of CGMP validation procedure for biopharmaceutical processes and products; and biopharmaceutical drugs research, design and delivery systems.

Specific examples of projects recently carried out within the institute are: development of Fourier transform infrared spectroscopy for the on-line monitoring of substrate, product and cell concentrations; kinetics of recombinant microbial and cell culture systems analysis of nutritional limitations and medium formulation for mammalian cell systems; use of cell cycle for enhancing mammalian cell culture productivity; fundamental studies of separation systems such as continuous chromatography, and aqueous two-phase extraction; plasmid DNA and recombinant protein purification; fundamental studies of protein conformation in bioprocessing by 2D FT-HNMR; perfusive effects in chromatographic separations; effect of cross-linking on biological activity of biopharmaceuticals; kinetics and enzyme production by cellulosic fungi/actionamycetes; bioprocessing equipments cleaning and validation.

The research is conducted in Iacocca Hall, Mountaintop Campus, where the laboratories for the Department of Biological Sciences research group, the Department of Chemical Engineering, the Emulsion Polymers Institute, and the Chemical Process Modeling and Control Research Center are located. Because of the interdisciplinary nature of the research, projects typically involve joint supervision by faculty from chemical engineering, molecular biology, and chemistry/biochemistry.

The Biopharmaceutical Technology Institute presently occupies 3600 square feet of laboratory and 2250 square feet of pilot plant space in the C wing of Iacocca Hall of the Mountaintop Campus. The institute is equipped with 30/250L of pilot-scale computer-controlled bioreactors, monitored and controlled by Leeds & Northrup MAX 1 Distributed Digital Control Unit. In addition, numerous small-scale reactors are available for batch and continuous culture work. Key emerging monitoring systems used on the pilot-scale fermentation equipment include a Uti Quadrapole Mass Spectrometer, BioChem Technology Fluorometric System, and an ASI ReactIR 1000 FTIR Spectrophotometer with steam sterilizable DiComp™ probe.

The fermentation and separations facilities supported by analytical equipment and facilities including UV/Visible spectrometer, isocratic and gradient HPLC's, with refractive index and variable wavelength UV/visible detectors, gas chromatographs with FID and TCD detectors, YSI analyzer, Branson cell sonifier, incubator/shakers, laminar flow hood, microscopes, centrifuges and ultracentrifuges, scintillation and gamma counters, liquid and gas liquid chromatographs, high-field NMR, etc.

Mammalian cell cultivation is conducted in a recently constructed class 100 laboratory equipped with CO2 incubators, vertical laminar flow hoods, Bellco roller bottle apparatus, Millipore Milli-Q purification system, inverted microscope, etc.

Educational opportunities. As listed in the course descriptions for the Department of Chemistry and Department of Chemical Engineering, the faculty of the Biopharmaceutical Technology Institute conduct a variety of courses as part of the graduate education curriculum in biochemical engineering and chemistry. The typical graduate level biochemical engineering curriculum would include core courses in chemical engineering and basic science courses in microbiology, biochemistry, and molecular biology offered through the departments of biological sciences and chemistry.

For more information, write to Dr. James T. Hsu, Director, Biopharmaceutical Technology Institute, Lehigh University, 111 Research Drive, Bethlehem, PA 18015.

Building and Architectural Technology Institute

BA TI is concerned with the entire scope of the built urban environment, the social, and the cultural aspects of building technology. BA TI researchers and faculty carry out bordercrossing studies aimed at the development of enhanced livability of the urban environment and its structures, their suitability to the environment for which they are planned, mutations in urban function and conditions, and the concurrent architectural, urban planning, and design problems.

The institute provides a center for interdisciplinary study, research activity, information dissemination, and stimulation for the use of new information in design. BA TI has as its goal both the enhancement of academic knowledge through academic research and the practical solution of current physical problems through applied research.

BA TI provides a forum for faculty discussion, not only from the different disciplines on the campus as they relate to the built environment (architecture, history, sociology, psychology,
business, and economics), but also for visiting fellows and professors. It also provides a contact between the academic and the business worlds.

**Research activities.** The institute provides the opportunity to identify research problems, develop proposals, and seek mechanisms for their solution. This can include the traditional single-discipline approach, but typically it involves work across the disciplines within the university and with other academic and commercial entities.

**Educational opportunities.** The resources of the institute, the Council on Tall Buildings and Urban Habitat, and other related centers at Lehigh University are available to interested scholars. For more information write to Dr. Tom F. Peters, Director, Building and Architectural Technology Institute, Lehigh University, 17 Memorial Drive East, Bethlehem, PA 18015-3007.

**Center for Innovation Management Studies**

The Center for Innovation Management Studies (CIMS) was established in 1984, in response to the needs of industrial executives and government officials for a university-based center to study the management of research and development and technological innovation. The center's research program is interdisciplinary and involves research across several other universities. The center supports studies of the industrial innovation process, encourages publication in the professional literature, and trains students and business executives for technology management responsibilities through regular course offerings and continuing education programs.

The goal of this research is to enhance the contribution of technology to corporate performance and national productivity through an improved understanding of the technological innovation process and its management.

Under the direction of Alden S. Bean, Kenan Professor of Management and Technology and former director of the division of policy research and analysis at the National Science Foundation, the center is sponsored by ten corporations and NSF.

For more information, write to Alden S. Bean, Director, Center for Innovation Management Studies, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015, or call (610) 758-3427.

**Center for Manufacturing Systems Engineering**

The Center for Manufacturing Systems Engineering serves as a catalyst between industry and the University community for coordination and development of campus activities associated with manufacturing. The center was created in response to the expressed needs of industry for educational and research services which were distinctively cross-disciplinary. A primary responsibility of the center is the administration of an award winning educational program which leads to a Master of Science degree in Manufacturing Systems Engineering. This world-renowned program started in January of 1984 as a result of a major initiation grant from the IBM Corporation. It now has 333 alumni who are working as managers and technical leaders in industry around the world. The center works with an Industry Advisory Board to ensure that classroom instruction is current, and that research goals are compatible with the long-range needs of industry. The center has four major thrusts: 1) A graduate program which offers a tightly focused one-year curriculum leading to the master of science degree in MSE, with a "part-time" two-year option. 2) Research directed at solving problems of manufacturing; this also serves to maintain faculty currency and provides a vehicle for student project and thesis studies. 3) Technology transfer to sustain the free flow of knowledge from the research laboratories to industrial applications, and from leading-edge member industries back into the classrooms. 4) The provision of services by offering conferences, clinics, workshops and other means for communicating and disseminating the advantages of sound manufacturing systems engineering practice.

**Graduate Education.** The 30-credit master's degree MSE program is cross-disciplinary, administered by the College of Engineering and Applied Science, with additional courses provided by the College of Business and Economics. Six core courses, 2-3 graduate level elective courses and a 3 or 6-credit research project or thesis are requirements of all candidates for the M.S. degree. Special activities in the program are team intensive and include in depth studies of companies, tours of industry, industry-related research and internships.

The full-time MSE program is designed as a one-year program that leads to a Master of Science degree in Manufacturing Systems Engineering. We also offer a two-year, part-time Program designed for employees of Lehigh Valley and neighboring companies. This option includes four semesters of one evening and one day per week attendance plus an industrial research project. Several MSE courses are now available via satellite through the Office of Distance Education.

Admission to the MSE program is achieved by application through the program and the department of the appropriate engineering discipline. The center is NOT a department and graduate students come under the department of whichever discipline happens to be appropriate, and must meet the standards required by that department. Candidates who wish to pursue a doctorate focused on aspects of MSE must apply for entry to the Ph.D. program of the department of their choice.

**Research Activities.** The center supports research in manufacturing systems engineering by means of grants to faculty, and support of research assistants; students in the MSE program are also encouraged to undertake research of interest either to their employers, or to industry in general. A current focus of research activities is microelectronics manufacturing and especially packaging, design systems, thick film hybrids, the characterization of coatings and package interfaces, and the use of lead free solders. The microelectronics manufacturing laboratory which was set up by means of grants and equipment from the A&T Foundation and IBM Corporation possesses equipment for thick film hybrid manufacturing and other processes. The purpose of this laboratory is to provide research capability together with hands-on experience. Other topics of interest range from studying the manufacturing systems aspects of designing and delivering electronic functionality in a variety of forms to theoretical modelling and simulation work. There are investigations into activity-based costing, design management, application of financial information systems, injection molding, together with research in various labs on the Lehigh campus. Investigations have been completed on applications of 3-D lithography in rapid prototyping. There are additional activities examining impacts of total quality and ISO 9000. There is particular interest in the development of intelligent process diagnostic techniques and their application to small and medium sized enterprises (SME's). The center supports activities of various university laboratories engaged in studies relating to manufacturing systems, however, the center does not operate any laboratories. There is collaboration with other centers, departments and laboratories in the preparation and planning of research proposals and programs which aim to improve the understanding of manufacturing.

For more information, write to: Keith M. Gardiner, kg03@lehigh.edu, Director, Center for Manufacturing Systems Engineering, H. S. Mohler Laboratory, Lehigh University, 200 W. Packer Avenue, Bethlehem, PA 18015, or call (610) 758-5157 or visit our website at www.lehigh.edu/~imee/center/
provides a unique opportunity for faculty and students from the traditional departments of chemistry, chemical engineering, materials science and engineering, mechanical engineering and mechanics, and physics to perform interdisciplinary research in polymers. The center is an umbrella organization encompassing polymers research and graduate studies at Lehigh University. The center’s primary missions are preparation of first-rate scientists and engineers with proficiency in polymers, fostering cross-disciplinary polymer research, organizing and teaching continuing education short courses in areas of interest to the polymer industry; and organizing campus wide seminars.

The center’s Polymer Education Committee graduate studies through the academic departments leads to the Master of Science and Doctor of Philosophy in Polymer Science and Engineering. Students may also elect to pursue studies towards a classical degree in their respective departments with an emphasis in polymer courses and research. Both advanced undergraduate and graduate courses in polymer science and engineering are offered through the participating departments. Current course offerings include polymer synthesis and characterization laboratory, physical polymer science and organic polymer science, engineering behavior of polymers, rheology, polymer processing, emulsion polymers, polymer blends and composites, fatigue and fracture of engineering materials, colloid science, and polymer interfaces.

Research activities. The center has a wide range of research activities covering the field of polymers. The following are the major research themes: emulsion polymerization and latex characterization, surface/interfacial aspects of polymer colloids, adhesion, and polymer blends and composites; polymerization mechanisms and kinetics; polymerization reactors, modeling and control; structure/property relationships of interpenetrating polymer networks; macromolecular chemistry of biopolymers and coal; polymer coatings for corrosion protection, and electronic packaging.

Research facilities. The following research instrumentation is available for the Center for Polymer Science and Engineering: X-Ray Photoelectric Spectroscopy (ESCA), Scanning Auger Electron Spectroscopy, Laser Ramon Spectroscopy, Mass spectrometry, Nuclear Magnetic Resonance Spectroscopy of both solids and solutions (NMR) (3 instruments: 90 MHz, 300 MHz and 500 MHz), Fourier Transform Infrared Spectroscopy (FTIR), Hydrodynamics analysis, instruments for rheological studies (including a Rheometrics RDA2 and Bohlin Rheometer), particle sizing instruments (Coulter N4M, Joyce-Loeb! Disc Centrifuge, Capillary Hydrodynamic Fractionation, and Hydrodynamic Chromatography), Gel Permeation and Gas Chromatography units, Electroencephalography apparatus, mechanical testing devices such as the Rheovibron Dynamic Mechanical Spectroscopy, Instron Tensile Test equipment, several computer-controlled servohydraulic fatigue test machines, and Polymerization Reactors, including Bottle Polymerizer, Tubular Reactor, Stirred Tank Reactors with on-line sample analysis for residual monomer and interfaced with computer for control operations.

Educational opportunities. Programs of study for individual students are designed to meet the student’s interests, the requirements of the academic department, and the student’s dissertation committee. Considerable flexibility is permitted in the selection of courses and a research topic. Lehigh University has been awarding interdisciplinary M.S. and Ph.D. degrees in Polymer Science and Engineering since 1975. Graduate students conducting polymer research may also earn the M.S. and Ph.D. degrees in the classical fields of chemistry, chemical engineering, materials science and engineering, physics, or mechanical engineering and mechanics. For further information please refer to the Polymer Science and Engineering Program in the section: Interdisciplinary Graduate Programs.

For more information about the center activities, admission to graduate school, or financial aid, contact: Dr. Mohamed S. El-Asser, Director, Center for Polymer Science and Engineering, Iacocca Hall, Room D330, Lehigh University, 111 Research Drive, Bethlehem, PA 18015, (610) 758-3590 or Dr. L. H. Sperling, Chairman, Polymer Education Committee, Lehigh University, 5 East Packer Avenue, Bethlehem, PA 18015, (610) 758-3845. Please address applications to one of the participating departments. Please visit the web site: http://www.lehigh.edu/~esd00/cpsel/home.html or e-mail msc0@lehigh.edu or lbs0@lehigh.edu.

Center for Social Research

The Center for Social Research is a multidisciplinary organization designed to stimulate and conduct research involving the social and behavioral sciences.

Several disciplines are involved in the activities of the center: psychology, sociology, anthropology, and education. The center also cooperates with the university’s other research centers and with several science and engineering departments.

Founded in 1965 as the Center for Business and Economics, the focus of the center was later broadened, and the name changed to the Center for Business, Economics and Urban Studies. The center’s early activities included research on economics and business forecasting, and on transportation problems. The change to include urban studies broadened the center’s scope to encompass the disciplines of political science, sociology, and history. In 1972, the center’s scope was further broadened to include behavioral science and international affairs, and the present name was selected to more accurately reflect this broadened focus.

Interdisciplinary research. The social perspective of the center’s research is interdisciplinary in nature and is relevant to the community outside the university—local, regional, national, and international. Many research activities are based on a cooperative university-community relationship through which the research goals of the center are achieved and community needs met. Interdisciplinary research activities of the center are currently being conducted in the following areas:

Health and Human Development. Members of the departments of psychology, sociology/anthropology, and education, participate in research on health and human development. The program focuses on life from early childhood to maturity. Research interests include the effect of perinatal loss on families and family members; the influence of family and community on health; management aspects of organizations that serve elderly individuals; psychological aspects of aging; and, psychological aspects of late life physical disabilities such as stroke and amputation.

Families and Children. Members of the departments of psychology, sociology/anthropology, and education participate in studies pertaining to families and children. Research interests include family dynamics and child rearing practices and the emphasis on families included under the health and human development program. Current research focuses on the effect of compensatory education programs evaluation methodology.

Program evaluation. Members of the departments of psychology, sociology/anthropology, and economics, participate in research to evaluate the effects of a variety of programs. Particular emphasis is on improving program evaluation methodology. Current research interests include evaluation of several business, science and engineering programs in the university. Research has recently been conducted on the effect of compensatory education and social service programs.

For more information, write to Diane Hyland, Director, Center for Social Research, Lehigh University, 516-520 Brodhead Ave., Bethlehem, Pa. 18015.

Chemical Process Modeling and Control Research Center

The mission of the Chemical Process Modeling and Control Research Center is the development and application of advanced process modeling and control techniques to improve chemical process productivity, enhance product quality, and assure
The Chemical Process Modeling and Control Research Center was established in January, 1985 through the efforts of faculty members of the chemical engineering department at Lehigh University, leading industrial processing companies, the Ben Franklin Partnership Program of the Commonwealth of Pennsylvania, coupled with the organizational and financial support of the National Science Foundation (NSF). Many of the original industrial member companies have been continuous supporters of the center.

The center provides a unique atmosphere for fundamental research, development of specific techniques, application to real industrial processes, and opportunities for advanced education in chemical process modeling and control for academics and industrial practitioners. Facilities are available for real-time testing of new algorithms in experimental process units, development of dynamic simulations of real processes, and the close collaboration with researchers in several other fields of chemical processing.

Interdisciplinary collaboration is encouraged with other research groups, centers or institutes engaged in biotechnology, polymer processing, environmental science, applied statistics, signal processing, chemical reaction engineering, and process design.

Direct industrial benefit is realized by participation in the center by a number of companies through an industrial consortium and its advisory committee. This committee actively participates in setting the research areas; collaborates with the center faculty, students, and staff in program assessment and implementation and provides a portion of the funding for the operation of the center.

**Education.** An integral part of the center is the commitment to conduct an outstanding program dedicated to the education of undergraduate and graduate students. The center has and continues to attract top quality students from a large group of well-recognized international universities. In addition to these gifted students, each year several industrial companies send employees to receive advanced training and engage in research efforts for particular company technical requirements. Because of the recognition of the value of the program and the quality of the students, the center has established a worldwide reputation as an outstanding educational and research unit in this critical area of technology development and implementation. More than a dozen graduate students are engaged in the center’s research efforts and are candidates for Ph.D. and masters degrees in this area of specialization.

**Faculty.** The center brings together more than a dozen faculty members and research staff from different engineering disciplines in the university engaged in the research and educational efforts of the center. Visiting faculty from other well-recognized universities supplement these researchers and provide opportunities for diversity of thinking and innovative research. All of the associated faculty members are recognized around the world as leaders in their respective fields of specialization.

**Facilities.** The Center is located at Iacocca Hall on the Mountaintop Campus of Lehigh University. This building represents a unique facility available to the center as well as the chemical engineering department and the Emulsion Polymers and Bioprocessing Institutes. The center has the use of several dedicated computer facilities with more than 50 PC or workstation computers continuously available to the students, faculty and staff. In addition to the local computing network, the center’s researchers have access to the Lehigh University central computing facilities and its outside links to other worldwide computing systems and data networks. The center has several laboratories with sophisticated equipment dedicated to process control research work.

**Areas of Research.** The research activities of the Center are grouped in the following four focus areas that are briefly described in the following: I) Tendency Modeling, Optimization and Control of Batch Processes, II) Statistical Process and Controller Monitoring, III) Nonlinear Model-Predictive Control and Closed-loop Identification, and IV) Integration of Process Design and Control.

I. Tendency Modeling, Optimization and Control of Batch Processes: Instead of either working with very detailed models that are not easily developed or with approximate input-output models that do not incorporate all existing knowledge of the process, a novel methodology, called Tendency Modeling, has been developed for batch reactors. This approach aims to use a model based on all the fundamental knowledge of the process as well as the available pilot or plant data. Model adaptation between batches has resulted in substantial process improvements within two or three adaptation cycles. Techniques for the quantification of the Tendency Model’s accuracy and the on-line model adaptation are the subject of present research. Besides batch procedure optimization, the Tendency Model can be used for the on-line estimation of important unmeasured process variables, such as compositions. Furthermore, they can be used in the implementation of model-based control strategies aiming to calculate the optimal batch time and to minimize the variability in the product quality. Important process applications in polymerization reactors, bioreactors, and organic synthesis reactors for specialty chemicals and pharmaceuticals aim to provide important process related results of value to industry as well as to enrich the generic methodology.

II. Statistical Process and Controller Monitoring: In meeting the goal of the continuous process improvement, a key strategy is the systematic identification and elimination of special causes of unexpected variation. This focal area is devoted to developing statistical methods that can be used on-line to monitor the behavior of the process and its controller(s).

By exploiting the nature of as well as the data available from continuous processes, methods have been developed that advance statistical monitoring far beyond the state-of-the-art as it exists in more traditional applications in manufacturing. Current center expertise in modeling, inferential measurements, principal component analysis, and model based control is drawn upon and enhanced through the research activities of this focus area. The basic approach pursued is to develop both knowledge-driven (i.e., fundamental) or data-driven (i.e., empirical) models for the monitoring of the process operation. Of specific interest is the identification of the occurrence, its character, and its point of origin. Most of the applications so far have been in the operation of continuous chemical processes, including the Tennessee Eastman process and the air separation plants of Praxair and BOC member companies. Furthermore, and in combination with the techniques of focus area on Tendency Modeling of batch processes, these multivariate statistical tools can be effectively applied to the operation of batch processes. Parallel statistical tools are presently being developed for the monitoring of the effectiveness of the controller structure active in a plant. These tools aim to provide an early detection signal for the need to retune the controller, redesign the controller structure, and possibly re-identify the process model use in model-based control strategies or inferential measurements.

III. Nonlinear Model-Predictive Control and Closed-loop Identification: Recent efforts to increase the process productivity and product quality of petroleum, chemical, and pharmaceutical processes have increased the importance of simultaneously controlling 20 to 30 process measurements, the presence constraints, and the effect of process non-linearities. The traditional unconstrained univariate linear controllers, e.g. bank of PIDS, are not well suited to handle these challenges. This realization has led to the development of various linear multivariable model predictive controller designs in the past.
decade. Because the process characteristics change during the operation of these controllers, there is a need to intermittently identify the process model in the closed-loop. Our recent efforts in this direction have developed a closed-loop algorithm based on the subspace identification framework. Continuing efforts aim to further develop this approach for constrained controllers and to apply and test it in challenging chemical process examples (e.g., Amoco FCCU, Tennessee Eastman plant simulation).

As the candidate processes for model predictive control have stronger nonlinear characteristics, the need for an effective nonlinear model predictive algorithm becomes more pressing. Past and present efforts in this direction have focused on the development of an approach based on the Reference System paradigm that the center introduced almost ten years ago. In this approach the controller tuning is done by the specification of the desired closed-loop response (Reference System) for each of the controlled variables. The controller utilizes this information and a nonlinear model to calculate the desired control moves.

The Diamond Center for Economic Education was established in 1976. It is part of a nationwide network of more than 270 such centers operating under the guidance of the National Council on Economic Education. It is also one of 15 centers in the state of Pennsylvania affiliated with the Pennsylvania Partnership for Economic Education. Like the organizations with which it is affiliated, the Diamond Center has as its principal mission the promotion of economic literacy in grades K-12.

For fifty years, the National Council has pursued this mission, and today it is the premier source of educational materials and curriculum reform in economics. It is estimated that its network of affiliates annually trains about 120,000 teachers in more than 2,600 school districts serving 7.5 million students.

Located in the Rauch Business Center, the center is part of the College of Business and Economics and is staffed by the Department of Economics. Each year it presents a variety of workshops and programs for teachers at various grade levels. These are designed to provide teachers with instruction and instructional material regarding economic ideas, institutions and facts of life. The center also serves as a clearinghouse for information on economic education and maintains a resource library of books, videos, curriculum materials, testing packets and simulation games for use by area educators.

For additional information about the Diamond Center, write to Director, Diamond Center for Economic Education, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015.

**Emulsion Polymers Institute**

The Emulsion Polymers Institute, established in 1975, provides a focus for graduate education and research in polymer colloids. Formation of the institute constituted formal recognition of an activity that had grown steadily since the late 1960s.

The institute has close ties with polymer and surface scientists in the Center for Polymer Science and Engineering, Polymer Interfaces Center, Zettlemoyer Center for Surface Studies, Materials Research Center, Center for Chemical Process Modeling and Control, and the departments of chemical engineering, chemistry, physics, and materials science and engineering.

**Polymer colloids** or polymer latexes, as they are more commonly called, are finely divided polymer particles that are usually dispersed in an aqueous medium. Important products produced and utilized in latex form include synthetic rubber, latex paint, adhesives and paper coatings. The small particle size of typical latexes makes their colloidal properties as important as the polymer properties in a number of applications. Hence, the study of emulsion polymers is an interdisciplinary activity.

**Research activities.** Emulsion polymers research includes a broad range of problems in the areas of preparation, modification, characterization, and application of polymer latexes. Most commercial polymer latexes contain a number of important ingredients, some in only small quantities.

Research programs at Lehigh are aimed at understanding the function of reactive components during the preparation and application of the latexes. The research projects are a blend of fundamental and applied efforts as well as a mixture of theoretical and experimental efforts to understand the effect that the chemistry and the flow behavior of the latex have on the structure. A typical methodology utilizes the technique of load rejection (plants with large capacitance and slow dynamics) and switchability (plants with low capacitance and fast dynamics).

For more information, contact Christos Georgakis, Director, Center for Chemical Process Modeling and Control, Jacobs Hall, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015-4791, (610) 758-4781; Fax: (610) 758-5297; E-Mail: C.Georgakis@lehigh.edu.

**Diamond Center for Economic Education**

The Diamond Center for Economic Education was established in 1976. It is part of a nationwide network of more than 270 such
or doctor of philosophy degree in existing science and engineering curricula or in the Center for Polymer Science and Engineering.

Programs of study for individual students are designed to meet the student's interests, the requirements of the appropriate academic department, and the student's dissertation committee. Considerable flexibility is permitted in the selection of courses and a research topic.

Faculty members of the institute are involved in teaching normal university courses and continuing education courses for industrial personnel. The annual one-week short course, Advances in Emulsion Polymerization and Latex Technology, typically attracts about 100 industrial participants and 20 Lehigh students. This course is an important mechanism for developing meaningful interactions between institute staff and students and industrial scientists and engineers. Educational and research opportunities exist for postdoctoral scholars and visiting scientists as well as resident graduate students.

For more information, write to Mohamed S. El-Aasser, Emulsion Polymers Institute, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, Pa. 18015. Please visit our web site at http://www.lehigh.edu/~esdolephihome.html

Energy Research Center
Energy research at Lehigh is a multidisciplinary activity, involving faculty and students from engineering, the physical sciences, life sciences, business, economics, and the social sciences. The Energy Research Center provides a structure within which faculty and students from different backgrounds can explore their specific research interests.

The center coordinates the university's energy research, helping the faculty respond to research opportunities and developments in energy. It is also the major contact between the university and industry and government for matters dealing with energy research. Originally founded in 1972 as the Task Force for Energy Research, the center was organized into its present form in 1978.

The research within the center involves a wide range of topics related to the supply and use of energy. Work in progress—supported by contracts and grants from government, industry, and private foundations—deals with fuels and energy resources, energy conversion systems, energy conservation and the environment.

The Energy Research Center has particularly close ties with industry. A number of joint research projects involve Lehigh faculty and students and research staff from industry. The center also operates the Energy Liaison Program, through which participating companies and government agencies have access to faculty consultants, make use of laboratory facilities and library services, and receive assistance on research problems, feasibility studies, and other projects related to energy. Through the center's Energy Intern Program, opportunities also exist for students to receive part of their training in industry. Through this program, a graduate student involved in energy can do a research internship in industry under the joint supervision of company research staff and the student's faculty adviser.

Experimental support for energy research is provided in a number of specialized laboratories maintained by the university. These laboratories, furnished with the latest instrumentation and equipment, include the following: boiling and two-phase flow, fluidized bed, fluid mechanics, surface chemistry, chemical kinetics, GC/MS spectrometry, atomic absorption spectrometry, electron optical, mechanical testing, structural testing, welding, metal forming, fracture mechanics, ceramics, polymer, hydraulics and water resources, van de Graff accelerator, biotechnology, aquatic biology, and microprocessor development.

All faculty members who participate in Energy Research Center activities belong to academic departments. In addition, a number of faculty and staff members affiliated with the center have close ties with other on-campus research centers and institutes, ensuring broad interactions between center personnel and experts from many research specialties, including economics, social science, materials and metallurgy, marine biology, fracture and solid mechanics, metal forming, structural design, sanitary and water resources engineering, thermal science, fluid mechanics, surface chemistry, and biotechnology.

Energy research. Research within the center falls within five major categories. Projects of interest include:

- **Fossil fuels.** Fluidized bed combustion of coal; heat transfer in fluidized beds, pulverized coal combustion, catalytic combustion, cyclonic combustion, coal slugging; freezing of coal, coal chemistry, microbial desulfurization of coal, kinetics of coal gasification, fluidized bed gasification, dynamic simulation of coal conversion systems, kinetics of coal liquefaction, hydrogen-enhanced crack growth in high-strength steels, organic coatings for flue gas desulfurization service, weld repair of steam turbine rotors, mechanical properties of cryogenic steels for LNG applications, toughness of pipeline steels, fracture analysis of pipelines, and mechanisms of tertiary oil recovery.

- **Nuclear technology.** Instrumentation for reactor safety studies; boiling heat transfer in water-cooled reactors; fracture toughness of reactor steels; static and dynamic fracture toughness of steel welds; microstructural characterization of pressure vessel welds; pressure vessel design, radioactive waste disposal; high-energy particle physics, and nuclear physics.

- **Environmental impact of energy systems.** Oil pollution studies in the coastal and wetlands environment, effects of power plant operations on biological life in the New Jersey estuarine region, acid rain, trace metal contamination of aquatic ecosystems, and hazardous waste disposal and control.

- **Conservation and renewable resources.** Biological conversion of cellulose to chemicals and fuels; catalysis for alcohols from biomass, energy recovery from municipal solid waste, fuel derived from waste water treatment, energy conservation in the metal-forming industries, instrumentation and analysis of industrial processes, use of computers for process control, development of microprocessors for residential load control, cooling of electric utility generators and high-capacity electric motors, design of cryogenic turbines, instrumentation for HVAC applications, and siting of wind-power applications.

- **Energy economics.** Dynamic analysis of energy supply-demand systems; model of an investor-owned electrical utility; and peak-load pricing of electricity and natural gas.

**Educational Opportunities.** The extensive involvement of faculty in energy research has created a wide range of opportunities for graduate studies in energy. Most of the departments in the College of Engineering and Applied Science, as well as several departments within the College of Arts and Science and the College of Business and Economics, are active in energy research and offer both masters and doctoral degree programs suitable for studies of energy-related topics.

All degrees are granted by the academic departments and graduate students interested in energy enroll in traditional graduate degree programs in departments of their choice. These students specialize in energy by completing their degree programs with a selection of special energy-related courses. They pursue their graduate research in energy areas under the supervision of faculty from the Energy Research Center or from other research centers or academic departments.

Opportunities also exist for students to receive part of their training in industry through a program in which a graduate student involved in energy can do a research internship in industry under the joint supervision of company research staff and the student's faculty adviser. The Energy Intern Program is individualized: each internship is designed to meet the specific needs and interests of the student, the faculty adviser and the company.

Financial support for graduate students is available through the Energy Research Center by means of fellowships and
research assistantships related to sponsored research.

Each year Lehigh faculty members offer a number of special energy-related courses at the undergraduate and graduate levels; many of them are outgrowths of current faculty research. Recent examples include courses dealing with energy economics, the international politics of oil, nuclear reactor engineering, public policy and nuclear power, air pollution, coal catalysis, coal technology, materials for modern energy systems, and solar energy.

The Energy Research Center also sponsors an annual seminar series, bringing outstanding people in the energy fields to campus to speak. Covering a range of topics from economics to energy policy to science and engineering, these seminars provide an opportunity for faculty and students to learn of new developments in energy.

For more information, write to Edward K. Levy, Director, Energy Research Center, Lehigh University, 117 ATLSS Drive, Bethlehem, Pa. 18015.

Engineering Research Center For Advanced Technology For Large Structural Systems (ATLSS)

The ATLSS Engineering Research Center was established in May 1986 with a grant from the National Science Foundation (NSF). The center is a national center for research and technology on structures and materials for the basic infrastructure of bridges, buildings, offshore-platforms, and ship structures. About 80 people, including graduate and undergraduate students, research associates, faculty and staff members representing the disciplines important to large structural systems are active at the center.

ATLSS research topics include Innovative Structural Systems and Materials, Condition Assessment and Life Prediction, Renewal Engineering, Life-Cycle Engineering and Information Systems, and Seismic Behavior. Projects follow the life-cycle processes of experimentation, design, fabrication and construction, operation, and renewal and retrofit. The studies are conducted in close association with engineers and scientists from industry, government, design and professional groups and other universities.

ATLSS has excellent research facilities and equipment, including two world-class structural testing facilities: the Fritz Engineering Laboratory and the major newer (1989) ATLSS Laboratory, in which researchers study large-scale complex connections, assemblages and structures under static, dynamic, and or cyclic multidirectional loading with complete computer-controlled experimentation. ATLSS also has outstanding resources for computing, mechanical testing, welding, metallography, and non-destructive evaluation.

Research Activities:

High-Performance Materials. Research is conducted on innovative structural forms and structural systems to promote competitive use of high performance materials, including high-performance steel, aluminum, concrete, fiber-composites, and mixed systems for bridge, building, offshore platform, and ship-hull applications.

Connection Design Methodologies. Research is conducted to advance connection technology in construction and to establish a connection design methodology. Connections for seismic resistance are emphasized.

Condition Assessment of Structures. Systems for corrosion and fatigue diagnosis, for bridge inspection and fatigue and fracture damage assessment are utilized for life prediction, condition assessment, and improved design specifications.

Renewal and Retrofit Techniques. To restore or increase structure durability and strength, renewal and retrofit technologies are studied for bridge, building and offshore-platform structures.

Educational Opportunities. The ATLSS Center facilitates programs of study and research that provide a fundamental, broad approach to the field of structures. Graduate students in the center's programs receive master of science, master of engineering, or doctor of philosophy degrees in the academic discipline of their choice, i.e., civil engineering, materials science and engineering, computer science, or mechanical engineering. However, they pursue course work related to a broader understanding of structures while conducting research in the center.

Financial support for graduate students is available through the ATLSS Center by means of fellowships and research assistantships related to sponsored research programs.

Undergraduates participate in the center's research through summer internships and academic-year special projects.

For more information, write to Dr. John W. Fisher, Director, ATLSS, Lehigh University, 117 ATLSS Drive, Bethlehem, PA 18015-4729.

Iacocca Institute

Over the years, Lehigh University has developed an impressive ability to forge university-industry-government partnerships. These partnerships are critical not only to the future of universities, but, also to improve U.S. competitiveness. It is primarily through partnerships - with companies, schools, government agencies and other universities - that the Iacocca Institute pursues its mission of advancing the global competitiveness of U.S. industry. Two of these partnering activities are the Global Village for Future Leaders of Business and Industry and the Iacocca Scholars Program.

The Global Village provides young adults from around the world the chance to experience the type of total-immersion leadership program usually reserved for top executives. Its purpose is to provide personal and organizational change needed to thrive in the emerging global economy. During the GV these interns who share the dream of a leadership career in business and industry, focus on leadership and entrepreneurial skills, global networking relationships, and business and industry knowledge. To date 110 interns from over 36 countries have graduated from the program and are now part of the growing list of Iacocca Institute Interns. The Global Village interns represent undergraduate students, MBA and graduate students, and managers from global corporations and family-owned businesses.

The Iacocca Scholars Program is a unique program that offers outstanding Lehigh students in all disciplines extraordinary opportunities to enrich their educational and leadership experiences, increase their awareness of issues related to global competitiveness, and provide skills required for success in the 21st century global marketplace. Established in 1993 with support and guidance from Lee Iacocca the scholars program is designed to develop future leaders. Each year, approximately 13 students are selected to be scholars on the basis of their interests in global competitiveness; demonstrated leadership ability; excellent academic achievements and potential; ability to use their talents to make a difference; and having a vision of their future and their role in giving as well as receiving. The scholars meet about twice a month for dinner, discussions, field trips, and to interact with high level executives. Iacocca Scholars and their faculty mentors also work on a creative, ambitious group project, which enables them to develop close personal relationships.

The Iacocca Institute was established in 1987 with the support of Lee A. Iacocca, former chairman and chief executive officer, Chrysler Corporation, and a member of Lehigh's Class of 1945. Mr. Iacocca chairs a distinguished advisory board, which provides close ties with industry. Its other members are Curtis H. Barnette, chairman and CEO, Bethlehem Steel Corporation; Jan S. Armfield, regional president, central PA, First Union Bank; Douglas A. Fraser, former president, United Auto Workers, university professor of labor studies, Wayne State University; William F. Hecht, chairman, president and CEO, PP&L; William C. Hittinger '44, former executive vice president, research and engineering, RCA Corporation; Russell Leslie, account executive,
Institute for Biomedical Engineering and Mathematical Biology
The Institute for Biomedical Engineering and Mathematical Biology was established July 1, 1988 to foster interdisciplinary research and support graduate study in the application of engineering and mathematics to medicine and biology. Faculty from several engineering departments and from mathematics and biology actively participate in the institute. Current research includes the mathematical analysis of transport and exchange in microcirculatory physiology, theoretical and experimental biomechanics, experimental biofluidmechanics, fracture and failure in skeletal units and in prostheses, shock propagation through the human body, and design for the handicapped.

Graduate students interested in studying biomedical engineering or mathematical biology at Lehigh enroll in one of the engineering departments or in the applied mathematics program, and satisfy the corresponding degree requirements. The institute provides the opportunity for interdisciplinary research for both the master’s thesis and the Ph.D. dissertation.

For more information, write to Eric P. Salathe, Director, Institute for Biomedical Engineering and Mathematical Biology, Chandler-Ullmann Hall, Lehigh University, 17 Memorial Drive East, Bethlehem, PA 18015.

Institute for Metal Forming
The Institute for Metal Forming was established in 1970 to teach the principles and applications of metal forming technology to graduate and undergraduate students, to provide instructions and equipment for graduate research in metal forming processes, and to assist industry with solutions to problems in metal forming.

The main objective of the institute’s research is to conduct cross-disciplinary process engineering studies to better understand and control manufacturing processes and their impact on the microstructural response of a material. Recently, classical metal forming research has been expanded to include projects in powder processing, microstructure analysis, and forming of polymers.

The study of metal forming encompasses viscoplasticity (physical modeling of a forming process); simulation of microstructure response to process parameters (via reproduction of the thermo-mechanical conditions that a material experiences during deformation); and computational numerical modeling. Computer enhanced analysis of material flow also allows us to optimize tooling design in many manufacturing processes. The combined quantitative results of these techniques may then be compared with experimental data obtained from instrumented metal forming laboratories (such as those maintained at the institute), or from our research partners in industry.

Research activities. Current research areas include: extrusion of metals, powders and polymers, sheet material formability, rolling, wire drawing, forging, semi-solid forming, light-optical and electron-optical micro-texture analysis, coatings of powders, tooling design and tooling materials, thermo-mechanical processing of metals, rapid prototyping, rapid tooling, and machinability of sintered powder materials.

Educational opportunities. Students interested in metal forming should refer to course offerings in the departments of materials science and engineering, mechanical engineering and mechanics, and industrial and manufacturing systems engineering.

For more information contact Wojciech Z. Misiolek, Director, Institute for Metal Forming, 242 Whitaker Laboratory, Lehigh University, 5 East Packer Avenue, Bethlehem, PA 18015.

Institute of Fracture and Solid Mechanics
The Institute of Fracture and Solid Mechanics was established in the fall of 1970 to enable faculty members and students within the university to participate in research relevant to fracture and solid mechanics on an interdisciplinary basis. A branch of this institute was established in the Republic of China in 1987 to carry out cooperative research activities.

An area of special interest to the institute has been in fracture mechanics, which deals with the study of structural and material sensitivity to flaws. Such flaws can seriously affect the design and strength of ships, aircraft, automobiles, bridges and buildings. In the design of nuclear power plants, the incorporation of the fracture mechanics concept of safety in the presence of flaws is required. In addition, fracture mechanics is finding application in such areas as bone fracture, environmental cracking of pavements and structural members, the fracture of rocks, and erosion of materials by solid or water particle impingement.

The activities of the institute include: expansion of research capabilities to include the application of concepts of fracture mechanics to geology (rocks), medicine (bones), and composite materials; editing books on timely subjects in fracture and solid mechanics; compilation and collection of written materials to establish and maintain a special library of fracture mechanics; planning of conferences on fracture and solid mechanics; offering short courses and seminars on special topics; and conducting liaison programs with industry and government agencies.

Research activities. There are several research programs being conducted in solid and fracture mechanics, sponsored by industry and governmental agencies. They include:


Experimental: static and dynamic fracture toughness testing of metallic, nonmetallic and composite materials.


Educational Opportunities. Students interested in fracture and solid mechanics should refer to course offerings in the departments of mechanical engineering and mechanics, materials science and engineering, civil engineering, chemistry and biology.

For more information, write to Director, Institute of Fracture and Solid Mechanics, Packard Laboratory, Lehigh University, 19 Memorial Drive West, Bethlehem, Pa. 18015.

Institute of Thermo-Fluid Engineering and Science
The Institute of Thermo-Fluid Engineering and Science, established in 1978, provides a focus for research and educational activities in fluid mechanics, thermodynamics, and heat transfer.

This institute seeks to consolidate the substantial ongoing research effort in these fields, to aid in the further development of such research, and to facilitate the utilization of this interdisciplinary strength in the university’s educational programs.
Currently 28 full-time faculty and staff from the departments of chemical engineering, mechanical engineering and mechanics, mathematics, and physics are among the institute members. Graduate students and undergraduates as well as part-time and visiting staff members, join in the institute's activities.

Research facilities for thermo-fluids programs are based in the College of Engineering and Applied Science. Among the facilities available are laboratories for experimental investigations of fluid mechanics, gas dynamics, turbulent structure, solid-gas fluidization, boiling heat transfer and two-phase flow, refrigeration and heat pump systems, internal combustion engines, radiation and optical measurements, unit operations, thermodynamic properties, and reaction engineering. The university's Computing Center as well as various minicomputers are available for use in analytical computations.

The institute also conducts the Thermo-Fluids Liaison Program to promote the interchange of knowledge between researchers at Lehigh and engineers and scientists in industry and government. In cooperation with companies participating in the liaison program, the institute's staff members seek to apply their specialized capabilities in thermo-fluids to current industrial and governmental engineering and scientific problems.

Research activities. The institute's staff members are involved in three interrelated areas: fluid mechanics, heat transfer and thermal science, and applied thermodynamics and modeling.

Combining experimental investigations with theoretical analyses, the researchers seek to understand and quantify the phenomenological mechanisms governing thermo-fluid processes. This knowledge is then brought to bear on relevant engineering problems of current concern in such applications as energy conservation, power production, coal conversion, aerodynamics, weather modeling, and nuclear energy.

The institute's current research programs include more than twenty grants sponsored by industry and various governmental organizations. A wide spectrum of subjects are under investigation, including research on flow-induced vibrations, unsteady turbulent flows, coherent turbulent boundary layer structures, blade flutter in compressors and fans, stochastic optimal control, colloid size distributions by hydrodynamic chromatography, fluidized combustion of coal, heat transfer in fluidized beds, heat pump systems, two-phase flow instrumentation, boiling heat transfer and two-phase flows, and nuclear reactor thermal safety.

Educational opportunities. Formal courses in fluid mechanics, heat transfer, and thermodynamics are offered in the College of Engineering and Applied Science. Institute staff members regularly teach both undergraduate and graduate courses in the departments of mechanical engineering and mechanics, chemical engineering, and physics. Undergraduates can select a program of study, in consultation with their advisers, with emphasis on thermo-fluid sciences by elective choices among the departmental offerings. A formal minor program in fluid mechanics is available. Graduate studies leading to the M.S. or Ph.D. with concentration in thermo-fluids are available in the three departments.

Participation by both undergraduate and graduate students in the thermo-fluids research activities is encouraged. Many undergraduates participate as individuals or as groups in term projects under the supervision of institute faculty members. This provides an opportunity for interested students to obtain first-hand experience in pioneering thermo-fluids research. The research programs directed by institute staff members also provide support for graduate research assistantships, enabling selected graduate students to pursue their education and research in thermo-fluids on either a part-time or full-time basis.

In cooperation with various academic departments, the institute sponsors seminars by both staff specialists and by invited speakers from other institutions. These seminars are open to the university community, liaison program participants, and to engineers and scientists from neighboring industries. The institute anticipates organizing topical meetings, workshops, and short courses on specialized subtopics within the over-all discipline. Meeting topics will be selected to reflect ongoing research activities of the staff members and contemporary engineering concerns.

For more information, write to John C. Chen, Director, Institute of Thermo-Fluid Engineering and Science, laccoca Hall, Lehigh University, 111 Research Drive, Bethlehem, Pa. 18015.

Lawrence Henry Gipson Institute for Eighteenth-Century Studies

The Lawrence Henry Gipson Institute for Eighteenth-Century Studies was established in 1971, to honor one of America's most distinguished scholars, who served as a long-time member of the faculty at Lehigh. Gipson's monumental life work, The British Empire Before the American Revolution (15 volumes) was written between 1936 and 1970. Gipson received the Pulitzer Prize in History in 1962 for Volume 10, subtitled, The Great War For Empire. When he died in 1971, Professor Gipson left his entire estate to Lehigh and provided the original endowment for the institute.

Research activities. The income from the endowment of the institute is used to encourage faculty and student research in the eighteenth century by providing small grants to defray travel costs, copying, and other expenses to permit scholars to visit necessary libraries and depositories. The Gipson Institute normally awards one fellowship annually to a Ph.D. candidate enrolled at Lehigh University for dissertation research and writing in any field of eighteenth-century studies. The institute also helps provide additional resources to build the university library's research collections in eighteenth-century studies.

Educational opportunities. The institute invites leading scholars to give occasional lectures and supports relevant programs such as interdisciplinary seminars and visiting scholars interested in the eighteenth century. Annual symposia honor Professor Gipson by bringing to campus distinguished scholars to lecture and discuss various topics. The essays generated at the symposia have been published and the institute maintains a continuing close relationship with Lehigh University Press for publishing original manuscripts on the eighteenth century.

For more information, write to either of the co-directors, Jean R. Soderlund, Department of History, Maginnes Hall, 9 W. Packer Ave., or Scott Paul Gordon, Department of English, Drown Hall, Lehigh University, 35 Sayre Drive, Bethlehem, PA 18015.

Philip and Muriel Berman Center for Jewish Studies

The Philip and Muriel Berman Center for Jewish Studies was established in 1984, develops, administers and coordinates a comprehensive program in Jewish studies at Lehigh University that also serves other member institutions of the Lehigh Valley Association of Independent Colleges (LVAIC) (Lehigh University, Muhlenberg College, Lafayette College, Moravian College, Cedar Crest College, and Allentown College of St. Francis de Sales). The Center for Jewish Studies is directed by Laurence J. Silberstein, Philip and Muriel Berman professor of Jewish Studies. The center supports and encourages shared course offerings as well as the exchange of faculty among LVAIC institutions. Faculty in Jewish Studies, housed at Lafayette College and Lehigh University, are associated with the center. In addition to teaching on their home campuses, these faculty offer Jewish studies courses on other LVAIC campuses each semester.

Activities of the center include designing and implementing new courses and seminars, establishing research grants for undergraduate students, sponsoring study programs abroad for undergraduates, organizing an annual lecture series, and sponsoring colloquia, conferences, and a publication series in Jewish studies. The center coordinates year-long, semester, and summer study programs in Israel at the Hebrew University and
Tel Aviv University. For further information on Israel study programs, contact Shirley Ratushny, (610)758-3352.

Philip and Muriel Berman of Allentown, Pa., in consultation with Judaic scholars from the United States and Israel, conceived of and provided the initial funding for the center. Their goal was to establish in the Lehigh Valley a first-class academic program for the study of all aspects of Jewish civilization. The center customarily opens its programs to the public.

For more information, write to Dr. Laurence J. Silberstein, Director, Philip and Muriel Berman Center for Jewish Studies, Lehigh University, 9 W. Packer Avenue, Bethlehem, PA 18015, or call (610)758-4869.

**Martindale Center for the Study of Private Enterprise**

The Martindale Center for the Study of Private Enterprise was established in 1980 by a gift from Harry and Elizabeth Martindale. The primary purpose of the center is to contribute through scholarship to the advancement of public understanding of the structure and performance of our economic system.

Attention is focused on the private sector of the economy and on public policies as they influence the private sector. To achieve this end, the center activities include the sponsorship of lectures and conferences, support of faculty research and case studies, and administration of the visiting scholar and executive-in-residence programs. The center sponsors and administers the Martindale Students Association Program (for undergraduates) and the publication of their journal, *Perspectives on Business and Economics*. The center has established the Canadian Institute which encourages scholarship dealing with the business and economic environment of Canada and with U.S./Canadian business and economic relations; and with U.S./Canadian and the public policy, and conferences, support of faculty research and case studies, and administration of the visiting scholar and executive-in-residence programs. The center sponsors and administers the Martindale Students Association Program (for undergraduates) and the publication of their journal, *Perspectives on Business and Economics*. The center has established the Canadian Institute which encourages scholarship dealing with the business and economic environment of Canada and with U.S./Canadian business and economic relations; and the Kalmbach Institute for the Study of Regional Political Economy which focuses attention on the business and economic environment of the Lehigh Valley and other regions throughout the U.S.

For more information, write to J. Richard Aronson, Director, Martindale Center for the Study of Private Enterprise, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015.

**Materials Research Center**

The Materials Research Center was established in 1962. Currently, approximately 140 people, including graduate students, research associates, and faculty members representing science and engineering departments, are engaged in research pertaining to materials science and engineering.

The fundamental objectives of the Materials Research Center are to encourage interaction among the science and engineering disciplines with an interest in materials and to promote interdisciplinary research activity and interdepartmental educational opportunities. To achieve these objectives, the center seeks to establish a climate in which faculty members, research scientists, postdoctoral associates, and graduate assistants develop an awareness of materials, arrange for facilities and space required to conduct interdisciplinary research; to guide the search for new materials by encouraging fundamental research and new approaches to materials problems; and to assist in developing educational opportunities in materials—in particular, interdisciplinary graduate programs devoted to training for research in materials.

The center also conducts the Materials Liaison Program. Founded in 1963, this program promotes the interchange of knowledge between the materials community at Lehigh and engineers and scientists in industry and government. The program conducts seminars on materials research, special lectures and workshops on items of current interest, consults on materials problems and research, distributes master of science and doctor of philosophy theses and abstracts of materials research, and sponsors seminars with outstanding invited speakers.

The staff consists of members of the departments of chemistry, chemical engineering, materials science and engineering, mechanical engineering, and physics. Members of other departments and centers frequently are involved in cooperative programs.

**Research Activities.** The present organization of the Materials Research Center includes six laboratories: the ceramics, electron microscopy and microanalysis, engineering polymers, mechanical behavior, microelectronic packaging materials, and thin films and coatings laboratories, all located in Whitaker Laboratory. Current interdisciplinary research activities include:

- **Ceramics.** Microstructure and solid-state chemistry of electronic and electro optic oxides including both polycrystalline and single crystalline materials; degradation mechanisms in ceramic devices; deformation mechanisms, including creep and hot pressing, contact damage and indentation behavior; sintering studies and additive effects; microstructural characterization of ceramic materials; microstructure design of multi-phase structural ceramics for optimum mechanical behavior; defect structure and impurity interactions in insulating, semiconducting, and superconducting oxides in both bulk and thin-film form; and interfacial segregation and phase formation in metal-oxide systems.

- **Electron Microscopy and Microanalysis.** Characterization of fracture surfaces in polymers, ceramics, and steels by scanning electron microscopy; ferrous alloys, geological materials and ceramics using the electron probe microanalyzer; transmission and scanning transmission electron microscopy studies of grain boundaries in oxides; metals, domain structures in ferroelectronics; low-temperature phase transformations in iron alloys; reactions in thin films; interfacial reactions in composites; and chemistry of nanometer-size catalyst particles.

- **Engineering Polymers.** Structure, morphology and mechanical behavior of interpenetrating polymer networks; thermosetting resins; vinyl polymers; polymers based on renewable resources; and permeability and mechanical behavior of membranes, coatings, and filled polymers.

- **Mechanical Behavior.** Effect of polymer chemistry and molecular structure on fatigue crack propagation (FCP), test frequency sensitivity and fatigue fracture micromechanisms in polymer solids, metallurgical aspects of FCP in ferrous and non-ferrous alloys, fracture mechanics of functionally gradient materials, fracture mechanism studies by transmission, and scanning electron microscopy.

- **Microelectronic Packaging Materials.** Characterization of materials used for the packaging of microelectronic circuits with an emphasis on reliability; application of fracture mechanics to organic passivation coatings, organic die attach adhesives and liquid encapsulants; finite element modeling of dual-inline packages, plastic quad flat packs, and C4 packages; surface characterization to predict adhesion; and application of fluorescence to study diffusion of water in polymeric materials and at interfaces.

- **Thin Films and Coatings.** Thin films of conducting, superconducting, magnetic and insulating materials; coatings for corrosion and wear resistance; processing facilities such as sputtering, plasma enhanced and electrodeposition; and characterization by electron and optical microscopy, differential calorimetry and x-ray diffraction.

**Educational opportunities.** This center facilitates programs of study and research that cross the traditional boundaries of science and engineering curricula, providing a fundamental, broad approach to the field of materials science and technology.

Graduate students participating in the center's program usually receive master of science or doctor of philosophy degrees in the academic discipline of their choice, i.e., chemistry, physics, materials science and engineering, electrical engineering and computer science, etc.; or in an interdisciplinary program such as polymer science and engineering. However, they are
The Warren V. Musser Center for Entrepreneurship was established in 1988 through a major gift from Murray H. Goodman, '48. The center is a self-supporting, interdisciplinary unit of the College of Business and Economics. The center provides financial support and other assistance for undergraduate courses in real estate and real estate finance, supports scholarly research in real estate, and sponsors joint activities with practitioners in the real estate field.

Educational opportunities. The center provides resources for teaching undergraduate courses in real estate and real estate finance. Sponsored courses include FIN 240 - Introduction to Real Estate and FIN 336 - Real Estate Finance. In addition, the center sponsors a continuing series of seminars and presentations by real estate executives and practitioners. The center also serves as a clearinghouse for students seeking internships with real estate firms and related companies.

Research activities. Consistent with the university's encouragement of scholarly research, the center provides funding for faculty research in the real estate area. Funding possibilities include: summer faculty research grants; travel, telephone and administrative support; and grants for part-time graduate assistants. The center also maintains a file of sponsored research opportunities available through private foundations, government agencies and practitioner organizations and provides administrative support to faculty applying for such funding.

Practitioner Interaction. The third aspect of the center's activities is its interaction with practitioners in the real estate field. The increased emphasis on continuing education and research among real estate practitioner organizations, as well as Lehigh's proximity to major real estate markets, enable the center to engage the practitioner community in a variety of joint projects. These joint projects include: 1) sponsored research projects; 2) continuing education programs and short courses; 3) special conferences and events of national and/or regional interest; and, 4) center-sponsored databases and continuing activities of interest to the practitioner community.

For more information, write to Stephen F. Thode, Director, Murray H. Goodman Center for Real Estate Studies, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015, or call (610) 758-4557.

Musser Center for Entrepreneurship

The Warren V. Musser Center for Entrepreneurship was established through a generous grant from "Pete" Musser, Lehigh class of 1949, for the promotion of entrepreneurship among the students and friends of Lehigh University. Mr. Musser, chairman and CEO of Safeguard Scientifics, Inc., is a highly successful entrepreneur in his own right and an active supporter of entrepreneurial ventures by others. Creation of the Musser Center at Lehigh caps more than a decade of university activities dedicated to encouraging and recognizing the role of entrepreneurship in the American business system. The center enables Lehigh to provide new levels of support for the entrepreneurial spirit.

SBDC: Associated with the Musser Center for Entrepreneurship is the Small Business Development Center.

Established in 1978, the SBDC provides general management assistance to over 1,500 entrepreneurs and small businesses per year in the Lehigh Valley and surrounding areas. Primary funding for this program comes from a major grant from the U.S. Small Business Administration and the Commonwealth of Pennsylvania. The Musser Center provides supplemental support for the efforts of the SBDC and contributes money to enhance its mission and broaden its scope.

Specialized programs. The Management Assistance Program delivers general management consulting to existing small firms and start-up ventures. Services are offered to retail, service, wholesale, construction, and manufacturing firms. Support is offered through electronic data base research. Seminars are offered on many topics of interest to growing firms. The International Trade Development Program (ITDP) is a specialized outreach effort of the Small Business Development Center. The ITDP helps companies with exportable products to develop export marketing plans and establish direct contacts with international markets. Seminars, trade missions and research projects support the efforts of this program.

The Government Marketing Assistance Program assists potential suppliers to government in identifying and developing government related to government procedures are handled on a one-to-one basis. Trade fairs and seminars are also offered.

The Financing Assistance Program provides assistance in loan packaging and financial planning and helps clients identify appropriate financing sources. The program administers the Lehigh Valley Small Business Loan Pool. Contracts with the Lehigh/Northampton Revolving Loan Fund, the Bethlehem Economic Development Corporation and other funding agencies provide resources for this assistance.

LUMAC. The Lehigh University Management Assistance Counseling program (a graded three-credit course) was established in 1972 on the initiative of undergraduate students. Through support from the SBDC, approximately 150 students per year gain practical experience by providing counseling to sixty businesses.

Future Global Entrepreneurs Club. The enrichment of entrepreneurship programs at Lehigh is accomplished in part by the Future Global Entrepreneurs club. Through this club, students meet entrepreneurs and promoters of new ventures.

SCORE. The Service Corps of Retired Executives is another affiliate of the Musser Center. SCORE, which works most closely with the SBDC, is chartered by the U.S. Small Business Administration and provides business expertise to current or potential business owners.

Liaison. Funding from the Musser Center assists other Lehigh University entrepreneurial activities. The Martindale Center for the Study of Private Enterprise uses funding to support student publications. The Center for Economic Education develops curricular materials for secondary school instruction on entrepreneurship. The Musser Center also conducts studies on the problems of business formation and operation and the characteristics of entrepreneurs.

For more information, write to John W. Bonge, Director, Musser Center for Entrepreneurship, Rauch Business Center, 621 Taylor Street, Bethlehem, PA 18015.

The Philip Rauch Center for Business Communications

Lehigh's College of Business and Economics recognizes a growing need for more effective communication in business. With the generosity of Philip Rauch, '33, retired chairman of Parker Hannifin Corporation, the college was able to meet this need and in 1981 opened a comprehensive business communications center.

The Center for Business Communications provides communication programs for Lehigh's undergraduate and graduate students and its surrounding community. These programs emphasize:
Business principles and theories underlying effective communication strategies.

Interpersonal communication skills: observing, listening, interviewing, team participation, and managing through leadership.

Strategies for crafting clear, concise business documents and oral presentations.

Strategies for relieving stage fright and developing exciting, memorable oral presentations.

In support of the undergraduate Writing Requirement Program in the College of Business and Economics, the Center's staff works with faculty from all academic areas to reinforce and improve student writing skills. The center operates a Business Writing Clinic, offering help to students in business-related courses, and maintains a homepage featuring links to online writing and speaking resources.

For more information, write John Bonge, Interim Director, Center for Business Communications, Rauch Business Center, Lehigh University, 621 Taylor Street, Bethlehem, PA 18015.

Polymer Interfaces Center
The Polymer Interfaces Center (PIC) is an Industry/University Cooperative Research Center that was established at Lehigh University in 1991. It is sponsored by the National Science Foundation (NSF) and is one of approximately 50 centers that have been established at universities throughout the U.S. in an effort to leverage industrial development with university science. In this arrangement, university professors, research scientists and graduate students conduct industrially relevant fundamental research while member companies and the NSF provide operating funds and guidance on the kinds of model polymers, model substrates and goals that are of interest to them.

PIC is developing a molecular-level understanding of the structural, dynamic, kinetic and energetic characteristics of the interphase region between polymers and substrates while also developing versatile methodologies to characterize the interphase region. Center research addresses such topics as adsorption, desorption, dynamic wetting, adhesion, charge transfer, transport, miscibility, compatibility and mechanical behavior. The center's ultimate goal is to generate a scientific database to assist in designing advanced polymers for such diverse applications as lubricants, water treatment, secondary oil recovery, coatings, inks, adhesives, and engineering plastics.

Research activities. The center is interdisciplinary and includes faculty from five academic departments: chemical engineering, chemistry, materials science and engineering, mechanical engineering and mechanics, and physics. The center also has four research scientists and engineers who help guide the research program. The current research effort is divided into two theme areas:

- **A. Polymer adsorption/characterization.** Investigators are elucidating the processes of water-soluble polymer adsorption and desorption from water onto colloidal and planar surfaces such as polystyrene, TiO₂, and silica.

- **B. Wetting/adhesion.** Using industrially important metal and plastic surfaces, researchers in this area investigate the fundamentals of wetting and adhesion and the means of varying these processes by altering the molecular structure at the interface. Another aspect of this theme is to examine the mechanical behavior of polymer interphases. Selected projects include investigations of film formation, role of mechanical interlocking on adhesions, and “toughening” mechanisms and fatigue resistance in plastics that are modified with rubbery and/or glassy inclusions.

Research facilities. Instrumentation available to PIC includes Atomic Force Microscopy in contact, non-contact and scanning tunneling modes; X-Ray Photoelectron Spectroscopy; Scanning Auger Electron Spectroscopy; Laser Raman Spectroscopy; Fourier Transform Infrared Spectroscopy; Attenuated Total Reflectance Infrared Spectroscopy; Dynamic Light Scattering; Total Internal Reflectance Fluorescence; Ellipsometry; Surface Forces Instrument; Laser Trap; Microcalorimetry; MoireInterferometry; Scanning Electron Microscopy; Transmission Electron Microscopy; Solid-State and Liquid-State Nuclear Magnetic Resonance Spectroscopy; Column Impregnation Units; Serum Replacement Cells; and a variety of Mechanical Property Test Equipment.

Educational opportunities. PIC supports graduate-level research for M.S. and Ph.D. degree students in subjects related to the center’s goals. Students receive degrees from their respective academic departments, but they also take special courses on polymer interfaces given by the center faculty and participate in the multidisciplinary activities of the center. There are a few opportunities for research by undergraduates who have achieved senior standing in a science or engineering major.

For more information, write Manoj K. Chaudhury, Director, Polymer Interfaces Center, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, PA 18015; or call (610) 758-3701.

Sherman Fairchild Center for Solid-State Studies
The Sherman Fairchild Laboratory was established by a major grant from the Sherman Fairchild Foundation and was opened in the fall of 1976. The laboratory houses an interdisciplinary staff consisting of faculty and students from the departments of physics, materials science and engineering, and electrical engineering and computer science. While work on various aspects of solid-state science is carried out at many locations on the Lehigh campus, the Sherman Fairchild Center provides the focal point for studies of electronic materials and devices.

Research activities. The Sherman Fairchild Center's faculty and students have a wide range of interests that include experimental and theoretical studies of the physics of defects in non-metallic solids and of disordered materials; advanced semiconductor processing technology; and semiconductor device design, fabrication, and characterization. The materials systems of interest are equally diverse and include silicon, silicon dioxide, compound semiconductors, wide bandgap semiconductors (SiC, ZnSe, and GaN), ferroelectrics and glasses.

The Sherman Fairchild Center houses several experimental laboratories. The Microelectronics Research Laboratory provides processing facilities for the fabrication of MOS, CCD, MNOS, bipolar devices and integrated circuits. Available technology includes low-pressure chemical vapor deposition, RF metallization, plasma chemistry, lithography, oxidation and diffusion. A new Display Research Laboratory has been established for work on electronic devices and thin-film materials for large flat panel displays. The Compound Semiconductor Research Laboratory has facilities for processing and characterizing high-speed integrated circuits. A new facility for the growth of compound semiconductor thin films by metalorganic vapor phase epitaxy is being constructed.

A 3 MeV Van de Graaff accelerator provides a radiation facility that can be used to produce high energy electrons for the generation of point defects. Individual laboratories provide instrumentation for optical excitation and luminescence, electron paramagnetic resonance (EPR), deep level transient spectroscopy (DLTS), and Fourier transform infrared spectroscopy (FTIR) for the study of defects in semiconductor thin films. There are also facilities for the study of transport in mesoscopic devices at milliKelvin temperatures, Raman spectroscopy, and ultrasonic attenuation. Theoretical work is facilitated by the university's extensive network of workstations.

Current research programs include work on 1) VLSI microelectronics, a study of the characterization of small-geometry solid-state devices for VLSI with emphasis on CMOS transistors; 2) nonvolatile semiconductor memories that offer the possibility of a "semiconductor disk;" 3) SiC materials for...
application in power electronics at high temperature; 4) the fundamental properties of impurities and simple lattice defects in silicon and wide bandgap compound semiconductors; a variety of methods (crystal growth, diffusion, electron irradiation) are used to introduce defects which can then be studied by spectroscopic techniques that include electron paramagnetic resonance (both conventional and optically detected), deep-level transient spectroscopy, and infrared absorption spectroscopy; 5) the oxidation of Si, Ge, alloys and SiC with emphasis on the very early stages of oxidation and impurity enhanced oxidation; 6) quantum mechanical calculations of the structural, vibrational, and electronic properties of defects in SiO, and wide bandgap semiconductors like GaN; 7) the fabrication of prototype active matrix displays; 8) the fabrication and characterization of high speed, compound semiconductor integrated circuits; and 9) the collective dynamics of partially ordered and disordered ferroelectrics and glasses.

Educational opportunities. Graduate students associated with the Sherman Fairchild Center usually enroll for the master of science or doctor of philosophy degree in the traditional discipline of their choice, such as physics, materials science and engineering, electrical engineering, etc., with specific course requirements and research participation coordinated through the appropriate department chairperson. Students are financially supported by graduate fellowships provided by the Sherman Fairchild Foundation and/or by university resources. In addition, teaching assistantships are available through the departments and a number of research assistant positions are supported by research grants and contract awards obtained by the laboratory staff. All of these arrangements typically permit graduate students in the solid-state studies to take three courses per semester in addition to their teaching or research activities. There are numerous opportunities for undergraduate students to participate in the research activities of the center with the possibility of support during summer through the Fairchild Summer Scholar Program.

Small Business Development Center
(see Musser Center for Entrepreneurship)

Technology Studies Resource Center

The Technology Studies Resource Center, based in the College of Arts and Sciences, creates and disseminates materials and programming that will lead a wide range of people to an understanding of the mutual interaction of technology and social institutions and values. Through the center, academics from all disciplines can collaborate on research and develop educational opportunities in technology studies with academic colleagues and with nonacademic sponsors.

The Technology Studies Resource Center's activities embrace the needs of academics, pre-college and college students, and industrial, political, and public audiences, who seek information about technology as a force in contemporary society. Four principal areas of activities are the development and dissemination of resource materials, professional development programming, consultation, and stimulation and coordination of technology studies and research projects. Specific activities include: collecting and distributing college-level course syllabi in technology studies; publishing bibliographies in specific areas of technology studies; publishing the Science, Technology and Society Curriculum Development Newsletter; maintenance of a data base of personnel, curricula, and materials resources in technology studies; sponsoring conferences, workshops, seminars, and institutes in technology studies; and integrating technology studies material with existing high school curricula and developing better courses in science and mathematics in cooperation with regional administrators and faculty.

For more information write to Stephen H. Cutcliffe, Director, Technology Studies Resource Center, Maginnes Hall, Lehigh University, 9 W. Packer Avenue, Bethlehem, Pa. 18015.

Zettlemoyer Center for Surface Studies

The Zettlemoyer Center for Surface Studies was established on February 1, 1966. It is home to the National Printing Ink Research Institute, which was established at Lehigh University in 1946. The center has been successful in fostering interdisciplinary research in a broad range of surface-related phenomena including lipid membranes, catalysis, corrosion, environment-enhanced cracking in alloys, coatings, dispersions, printing inks, and colloids. Faculty members from the departments of chemistry, chemical engineering, mechanical engineering and mechanics, materials science and engineering, and earth and environmental sciences are associated with the center. The center develops and maintains research facilities, including laboratory and office space, and major experimental equipment used in interface and surface-related research. The center facilitates interchanges of ideas and interactions between faculty and students from different disciplines, thereby nurturing research at the forefront of science and broadening the educational opportunities for graduate as well as undergraduate students.

Financial support for the center comes largely from projects with industries and governmental agencies. The center is well-equipped with specialty instrumentation needed for advanced research in its field, especially for in situ studies. Sinclair Laboratory houses equipment for experimental studies employing flash desorption, Auger spectroscopy, laser Raman spectroscopy, infrared spectroscopy, attenuated total reflectance infrared spectroscopy, X-ray photoelectron spectroscopy (electron spectroscopy for chemical analysis), high-resolution electron energy loss spectroscopy, low energy electron diffraction, ultraviolet photoelectron spectroscopy, nanosecond fluorescence spectroscopy, ellipsometry, nonlinear resonant sum frequency spectroscopy, ultra-high vacuum scanning tunneling microscopy, computerized optical spectrophotometry, diffuse reflectance UV/VIS/NIR spectrophotometry, microelectrophoresis, and continuous electrophoresis.

Other specialty equipment includes microbalances, integrated systems for continuous flow catalyst testing, testing machines for studies of environment-affected crack growth, gas adsorption for surface area measurements, and heat of immersion apparatus, wetting balances, apparatus for determining rheological properties, and apparatus for the preparation of reproducible dispersions and films.

Research activities. The center's research program includes a broad range of topics vital to modern science and technology. Some of the active topics are: solid-state chemistry of catalysts; catalytic oxidation of methane; mechanisms of catalytic reactions and development of new catalysts; chemistry of NO, abatement; formation of monolayer oxides on oxides of a different metal; the interaction between these oxides and relationship with catalytic activity; surface magnetic properties; wetting of multilayer systems; characterization of surfaces; adsorption at electrochemical interfaces; self-assembly of chemically bound multilayers at surfaces and interfaces; structure and dynamics of surfactants at interfaces; microelectrophoresis and continuous electrophoresis; erosion and wear; chemical composition of surfaces; passivity and corrosion inhibition; chemistry of fracture surfaces, hydrogen embrittlement; environmentally-affected crack growth; high-temperature corrosion; coatings for protecting microelectronic circuits; adhesion of coatings; corrosion under coatings; chemical state of ions in polymers; charge transport through organic coatings; effect of metallic cations on corrosion processes; water-based coatings; electrical properties of coatings; polymer surfaces; research related to lithographic, flexographic and gravure printing; rheology in non-Newtonian fluids; adhesion and flow of fluids in porous substrates; and computational chemical dynamics of surfaces, clusters, and zeolites.

Educational opportunities. The center is a facility in which graduate students undertake thesis and dissertation research
leading to the M.S. and Ph.D. degrees in the departments of chemistry, chemical engineering, physics, mathematics, biology, materials science and engineering, mechanical engineering and mechanics, and earth and environmental sciences.

Potential and current graduate students whose interests are consistent with the center’s objectives are welcome to avail themselves of the experimental facilities. Research assistantships are available. Research topics are selected by mutual agreement, and interested students are encouraged to explore research opportunities in the center.

The center’s research also forms the basis of continuing educational programs designed primarily for industrial personnel. The conference center in Sinclair Laboratory accommodates the special seminars and short courses that are held periodically. Recent course topics include corrosion, printing ink technology, and molecular design characterization of catalytic oxide materials.

The center provides opportunities for resident postdoctoral studies and for visiting scientists.

For more information, write to Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, 7 Asa Street, Bethlehem, PA 18015.

Ben Franklin Technology Center — Northeast Tier

The Ben Franklin Technology Center Northeast Tier is based on the Murray H. Goodman campus. The Center is part of a four-member system, the Ben Franklin Technology Partnership, which brings together the best of Pennsylvania’s people, ideas, and technology and serves as a catalyst for advancing the state’s manufacturing and business base.

The Ben Franklin Technology Partnership fosters innovation to stimulate economic growth and prosperity. The four centers collaborate with educational institutions, communities, other economic development organizations, and government to help companies and entrepreneurs succeed. By providing knowledge and investment resources, the partnership facilitates the creation of new products, sophisticated technologies and fresh ideas among entrepreneurs and established companies to help them prosper. The result: the creation and retention of good jobs and a strong economic climate for Pennsylvania.

Founded in 1983, the Ben Franklin Technology Partnership has:
- Created and retained over 3,000 jobs
- Established more than 1,400 companies
- Commercialized and implemented over 1,500 products and processes

The Ben Franklin program is structured to help companies achieve sustainable competitive advantage. Each center is measured on the basis of the commercial success achieved by its clients as a direct result of assistance provided.

Assistance includes expertise, largely contributed in the Northeast by the center’s association with Lehigh University and other leading research universities, and funding, with investments ranging from $10,000 to $100,000 per year for up to three years. Faculty and students involved with Ben Franklin gain experience in solving real issues for working businesses. Technical and business assistance services are provided on a year-round basis.

The Northeast Center operates a business incubator on Lehigh’s Mountaintop campus. The 12,000 square foot incubator currently holds ten start-up companies. Fifty companies have begun at the Northeast Center Ben Franklin incubator.

The goals of the Center include helping new technology-oriented businesses to form and grow, helping existing manufacturers to improve productivity through innovative application of new technologies and practices, and helping to insure a qualified work force by seeding the development of creative new education and training programs that are driven by the needs of industry. Through these activities, the program aims to create and retain high-quality, local job opportunities.

For the 1998 funding year, the Northeast Center was awarded over $6 million from the state Department of Community and Economic Development, with more than $16.5 million in matching funds committed from private-sector businesses, educational institutions and other sources. Last year, the Northeast Center had about 30 to 40 projects with Lehigh, involving many faculty members, research scientists, project engineers, students, technicians, and administrative staff.

For more information, contact Mark Lang, Executive Director, Ben Franklin Technology Center, Lehigh University, 125 Goodman Drive, Bethlehem, PA 18015-3715; 610-758-5200. E-mail: Mark@net.bfp.org

Council on Tall Buildings and Urban Habitat

The Council on Tall Buildings and Urban Habitat, an international organization sponsored by engineering, architectural, and planning professionals, was established in 1969 to study and report on all aspects of the planning, design, construction, and operation of tall buildings.

The council’s nine professional society sponsors are:
International Association for Bridge and Structural Engineering, American Society of Civil Engineers, American Institute of Architects, American Planning Association, International Union of Architects, American Society of Interior Designers, Japan Structural Consultants Association, Urban Land Institute, and International Federation of Interior Designers. In 1974 the council was admitted as a consultative nongovernmental organization to the United Nations Educational, Scientific and Cultural Organization.

The council is concerned with the impact of tall buildings on the urban environment and in the role they play in urban life. This involves a systematic study of the problem of providing adequate space for life and work, considering not only technological factors, but social and cultural aspects as well. Important activities include the identification and stimulation of needed research and implementation of findings into codes, specifications, and standards.

The eight groups that carry out the major activities of the council are:
- Urban Systems (US)
- Development and Management (DM)
- Planning and Architecture (PA)
- Building Systems and Concepts (BSC)
- Building Service Systems (BSS)
- Design Criteria and Loads (DCL)
- Tall Steel Buildings (SB) and Tall Concrete and Masonry Buildings (CB)

A major focus of the council is a comprehensive multi-volume monograph on the planning and design of tall buildings entitled Tall Buildings and the Urban Environment. They cover environmental aspects, transportation and other planning aspects; service systems, structural systems; the various loading systems; structural safety, foundations, and structural design methods and limit states—the latter covering both steel and concrete buildings.

The council is not an advocate for tall buildings, per se, but in those situations in which such buildings are viable, it seeks to encourage the use of the latest knowledge in their implementation.

The headquarters of the council is at Lehigh University. Nearly 1,200 specialists, primarily engineers, architects, planners, and sociologists from 70 countries, are involved in the work of its committees. A number of these committees provide advisory guidance for relevant Lehigh research projects.

For more detailed information, contact Lynn S. Beedle, Director, Council on Tall Buildings and Urban Habitat, Lehigh University, 11 E. Packer Avenue, Bethlehem, Pa. 18015; Phone: (610) 758-3515, Fax: (610) 758-4522; e-mail: incbuh@lehigh.edu. Visit our website under Research Centers and Institutes on Lehigh's homepage or at www.lehigh.edu/ctbhui.
Manufacturers Resource Center

The Manufacturers Resource Center (MRC) assists small and mid-size manufacturers in improving their productivity and quality, lowering their costs and improving their competitiveness utilizing current technologies and proven business techniques. The MRC is a first stop, full service, highly responsive, easy-to-use resource center providing information, problem solving and funding assistance.

The MRC is one of seven statewide Industrial Resource Centers (IRCs) and one of 70 federally funded National Institute of Standards and Technology (NIST) Manufacturing Extension Partnership (MEP) centers.

The IRCs are celebrating 10 years of providing manufacturers with assistance. Over the last ten years, MRC has worked with 466 companies on 1,551 projects. The top six industries MRC has worked with include industrial/commercial machinery, fabricated materials, electronics, rubber/plastics, primary metals and chemicals. The top six project types are quality management, business planning, management systems, business systems, quality inspection and human resources/workforce development. The four main products groups for MRC are quality, operations (including IT), business practices and workforce development.

The MRC serves Berks, Upper Bucks, Carbon, Lehigh, Northampton, and Schuylkill as an IRC and adds the following counties as its federal territory: Bradford, Columbia, Lackawanna, Luzerne, Monroe, Pike, Sullivan, Susquehanna, Tioga, Wayne and Wyoming. Services are delivered through experienced staff and industry professionals, private and academic consultants, customized training programs, library of manufacturing materials and data bases.

For further information or assistance, please contact Edith Ritter, Executive Director, at (610) 758-5599.
V.

Courses Programs and Curricula

This section includes listings of undergraduate and graduate courses offered by Lehigh University. For purposes of record, all approved courses are listed. It must be understood, however, that the offerings in any given semester are contingent upon a number of factors, including student needs as determined at the time of preregistration.

All academic departments are listed in alphabetical order.

Credit Hours
The number in parentheses following each course title indicates the credit value of the course in terms of semester hours ("credit hours").

Course Numbering
The course numbering system specifies which courses can be applied to the program of study as the student progresses toward the undergraduate or graduate degree. In general, the numbering series is as follows:

0-99. Courses primarily for freshmen or sophomores. Not available for graduate credit.

100-199. Intermediate-level undergraduate courses. Not open to freshmen except on petition. Not available for graduate credit.

200-299. Advanced undergraduate courses. Courses in the College of Business and Economics and specific departments as noted in the listings are open to freshmen and sophomores only on petition. Not available for graduate credit in the major field.

300-399. Advanced undergraduate courses. Same as 200-299, but available for graduate credit in major field.

400-499. Graduate-level courses, open to undergraduates only by petition.

Provisional Courses
Each instructional department is authorized to offer provisional courses, or those offered on a trial basis, as well as special opportunities courses. Such courses can become a permanent part of the university curriculum. These courses are numbered, as is appropriate, ... 95-98, ... 195-198, ... 295-298, ... 395-398, for a maximum of two semesters.

Apprentice Teaching and Cooperative Undergraduate Education
For details of these programs, see descriptions under "Apprentice Teaching" and "Cooperative Undergraduate Education," in section III.

Prerequisites
Academic preparation required for admission to courses is indicated under "prerequisites" included at the end of each course description. Prerequisites are stated in most cases for purposes of convenience in terms of Lehigh courses. Academic status required for admission, where numbering does not fully describe this status, is also indicated under "prerequisites."

A student who does not have the status (e.g., sophomore standing) or the academic preparation set forth as prerequisites must, in order to be admitted to a course, file with the registrar at the time of registration and on a standard form provided, a waiver of prerequisites signed by the course instructor, the teaching department chair and either the chair of the student's major department or the associate dean. Academic work completed elsewhere must be attested in this manner as being substantially equivalent to prerequisites listed, unless the student's records in the Office of the Registrar show that the proper officers have so evaluated this preparation previously.

In a few cases, corequisites are indicated. In such instances the corequisite course is taken in the same semester.

Information Limits
The course descriptions are intended to guide the student in selecting appropriate courses. For reasons of space, descriptions are brief. In most cases, courses will have a significantly broader scope than the topics listed in the description. In some courses, material may change from what is described. If there is doubt concerning the appropriateness of any course for the individual's educational objectives, it is suggested that the student confer with the adviser.

Abbreviations
Whenever possible, course listings contain information indicating what requirements the course satisfies, the semester or semesters in which it is offered, and the name of the scheduled instructor or instructors.

While all information herein is subject to change, the information is included to serve as a guide in the selection of appropriate courses that best fulfill the student's academic requirements and personal goals.

The symbols following course descriptions for some College of Arts and Sciences courses include:

HU. Courses that meet the Humanities distribution requirements.

NS. Courses that meet the Science distribution requirements.

SS. Courses that meet the Social Science distribution requirements.

MA. Courses that meet the Mathematical distribution requirements.

ND. Not designated to meet distribution requirements.

The symbols following course descriptions for some College of Engineering and Applied Science courses include:

ES. This code plus the following number indicates that the course satisfies a number of hours of engineering science requirements for ABET accreditation.

ED. This code plus the following number indicates that the course satisfies a number of hours of engineering design requirements for ABET accreditation.
Accounting

The mission of the Accounting Program is to provide rigorous and relevant accounting education that prepares high quality undergraduate students with diverse backgrounds for life-long learning and positions of leadership in the business community. Consistent with the missions of Lehigh University and the College of Business and Economics, the Accounting Program continuously seeks to be recognized as one of a select group of programs in the United States where an educational experience of the highest possible quality is obtainable.

Within the accounting major, there is an opportunity to explore the various career opportunities within the broad field of accounting: financial, managerial, taxation, auditing, and information systems. The program recognizes the learning objectives set forth by the College of Business and Economics as an integral part of the curriculum, as well as the importance of providing students with a strong foundation in liberal arts, humanities, and science as set out in the CBE core curriculum. In addition to the CBE core curriculum, the accounting curriculum is designed to foster the following learning objectives:

Skills:
- Develop students' oral and written communication skills.
- Develop students' interpersonal skills, including interpersonal dynamics, leadership, teamwork, and negotiation.
- Develop students' problem-solving skills, including critical thinking and decision-making skills.

Content:
- Develop in each student an appreciation for the role of the accounting profession in the external business environment including societal, global, technological, ethical, legal, and regulatory issues.
- Provide students with a perspective of the role of the accounting professional in the internal business environment, including business strategy, organizational structure and behavior, uses of technology, ethics, diversity, and the interrelationship of business functional areas.
- Provide students with a theoretical framework and develop their ability to apply problem-solving skills in the areas of financial accounting, managerial accounting, information systems, auditing, and taxation.

To the extent that the above objectives are achieved, Accounting Program graduates will be well-prepared for positions in public accounting, industry, not-for-profit organizations, and graduate school. Although preparation for professional examinations is not a primary objective of Lehigh's Accounting Program, students successfully completing the accounting major will have the background to take professional examinations in accounting.

The Undergraduate Major

The undergraduate program in accounting is accredited by the American Assembly of Collegiate Schools of Business. This achievement places the program within a small group of schools which have satisfied a rigorous examination of the program, faculty, and students beyond the accreditation standards applied to the College of Business and Economics undergraduate and graduate programs.

The accounting major offered in the Department of Accounting requires 15 credit hours beyond core requirements. In addition, accounting majors must take the Accounting Information Systems (Acct 311) alternative to BIS 211 (formerly Acct 211) to fulfill the information systems requirement for the accounting major.

Acct 307 Fundamentals of Federal Income Taxation (3)
Acct 315 Financial Accounting I (3)
Acct 316 Financial Accounting II (3)
Acct 320 Fundamentals of Auditing (3)
Acct 324 Cost Accounting (3)

Undergraduate Courses

Acct 108. Fundamentals of Accounting (3)
A one-semester survey of accounting principles and practices, including an introduction to industrial cost systems designed for those students planning to take only one accounting course. Other students should take the Acct 151-152 sequence.

Acct 151. Introduction to Financial Accounting (3)
The organization, measurement and interpretation of economic information. Introduction to accounting theory, concepts and principles, the accounting cycle, information processing, and financial statements. Exposure to controversial issues concerning income determination and valuation. Prerequisite: sophomore standing.

Acct 152. Introduction to Managerial Accounting (3)
An introduction to internal accounting information for all levels of management. Topics include cost flow in a manufacturing operation; planning, evaluating and controlling through budgeting and standard costing; and decision-making using cost-volume-profit analysis, direct costing, and relevant costs. Prerequisite: Acct 151.

For Advanced Undergraduates and Graduate Students

Courses numbered 200 and above in the College of Business and Economics are open to sophomores only on petition.

Acct 211. Management Information Systems (3)
See Business Information Systems Section (BIS 211).

An introductory study of the principles and concepts of federal income taxation of individuals, corporations, partnerships, and fiduciaries; and federal gift and estate taxes. Determination of tax liabilities and opportunities for planning are emphasized. Problem-solving using the source materials of tax law and tax research are important components of the course. Prerequisite: Acct 151.

Acct 309. Advanced Federal Income Taxation (3)
An advanced study of the taxation of business organizations, estates, trusts, and wealth transfer taxes. Planning and research are the basic components of the course. Problem-solving and written research are emphasized. Prerequisite: Acct 307.

Acct 311. Accounting Information Systems (3)
An introduction to the concepts underlying information systems as they relate to organizational structure, managerial decision making and accounting. The course acquaints students with the...
Africana Studies

Professors. William R. Scott, Ph.D. (Princeton), Professor of History, program director; Elizabeth N. Fifer, Ph.D. (Michigan), Professor of English; Jean R. Soderlund, Ph.D. (Temple), Professor of History.

Associate professors. Berriasford W. Boothe, M.F.A (Maryland Institute College of Art), Associate Professor of Art and Architecture.

Assistant professors. Mary Washington, Ph.D. (Johns Hopkins University); Assistant Professor of Sociology and Anthropology; Kashi Johnson, M.F.A (University of Pittsburgh)

Adjunct professors. Curtis Keim, Ph.D. (Indiana); Mildred Rivera-Martinez, Ph.D. (Stanford University); Sharon Levy, Ed.D. (Lehigh).

The purpose of the Africana Studies Program is to engender in Lehigh students an intellectual appreciation of the life and culture of people of African descent worldwide, especially in the United States, thereby enriching the Lehigh curriculum and increasing the relevance of a Lehigh education to a culturally diverse society and world. In the best tradition of a liberal arts education, Africana Studies expands all Lehigh students' critical understanding of their own heritage in interaction with other cultures.

The major and minor in Africana Studies is an interdepartmental and comparative program of study for undergraduates who wish to integrate the insights and methods of several disciplines to understand the history, culture, social, and political experience of people of African descent globally. The Africana Studies curriculum encompasses two intended lines of inquiry: (1) the diverse influences in Africa and the African diaspora that have shaped African American culture, and (2) the variety of ways that the African American experience has shaped and been shaped by American culture.

The Major

The major in Africana Studies consists of a minimum of ten (10) courses, constituting at least 30 credit hours and no less than four (4) upper level courses. It entails training across disciplinary lines as well as concentrated study in a single discipline:

Introductory Course (1)

Humanities (3)

Social Sciences (3)

Disciplinary Concentration (3)

In addition, students are encouraged to pursue independent study opportunities to enhance their knowledge of specific aspects of Africana Studies.

The Minor

The minor consists of a minimum of five (5) courses, constituting at least 15 hours of study that includes the introductory course and no less than two upper level courses in the field.

Core Courses:

Core courses concentrate on subject material directly relevant to the study of past and present experiences of people of African descent.

AAS 3. Introduction to Africana Studies (4)

An interdisciplinary examination of the roots, culture, and politics of the modern black world through study of classic works in Africana Studies with emphasis on the continuities among African peoples worldwide and the social forces that have shaped contemporary black life in Africa and the Americas. Scott. (SS)
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAS 5.</td>
<td>African Civilization (4) Sub-Saharan Africa through the millennia of the ancient world to the present. Human, state and non-state systems, the external slave trade; colonialism, resistance to European rule; independence movements; neo-colonialism. Keim. (SS)</td>
</tr>
<tr>
<td>AAS 38.</td>
<td>Introduction to African Literature (3) Sub-Saharan African literary themes and styles, historical and social contexts, African folk tales, oral poetry, colonial protest literature, postcolonial writing, films on contemporary Africa. Staff. (HU)</td>
</tr>
<tr>
<td>AAS 64.</td>
<td>plantation to Ghetto (2) Examination of topics in the economic history of African Americans from the 1500s to the present. Explores the slave trade, slavery, post-Civil War South, the black family, migration, urbanization, and race and poverty. O'Brien, Scott. (SS)</td>
</tr>
<tr>
<td>AAS 103.</td>
<td>Sociological Perspectives on Racial and Ethnic Communities (3) fall The objective of this course is to introduce students to the sociological and historical foundations of contemporary debates about the meaning of “race and ethnicity,” and the role these identities play in our understanding of economic, political, and social inequality. Although the course focuses primarily on the U.S., the student is also encouraged to consider the racial and ethnic organization of human societies and collectivities as a global phenomenon. Washington. (SS)</td>
</tr>
<tr>
<td>AAS 129.</td>
<td>Black Political Thought in America (4) Black leadership, organizations, and philosophy in America from Reconstruction to the Civil Rights Era; ideas and programs of Booker T. Washington, W.E.B. DuBois, Marcus Garvey, Malcolm X and Martin Luther King, Jr. Scott. (SS)</td>
</tr>
<tr>
<td>AAS 130.</td>
<td>African American History (4) Blacks in America from the first importation of Africans to the implementation of civil rights laws. West African origins, slave trade, slavery, free blacks and emancipation and study of Reconstruction, segregation, urbanization, and the struggle for racial equality. Scott (SS)</td>
</tr>
<tr>
<td>AAS 138.</td>
<td>Introduction to African American Literature (3) Survey of African American prose narrative and poetry from the 18th century to the present. Features writers from the Harlem Renaissance, the Black Arts Movement, and the post-Black Power era. Levy. (HU)</td>
</tr>
<tr>
<td>AAS 140.</td>
<td>African American Theatre (4) Foundations of African American theater: historical, literary, and practical. Staff. (HU)</td>
</tr>
<tr>
<td>AAS 142.</td>
<td>The Psychology of African Americans (4) Exploration of scholarship on the attitudes and actions of black Americans stressing the psychological dynamics, popular culture and behavior of contemporary African Americans. Staff. (SS)</td>
</tr>
<tr>
<td>AAS 145.</td>
<td>African American Women Writers (4) Literature by African American women writers with a focus on the experiences and images of black women in the U.S. Explores the written portraits and voices of 20th century black female novelists and poets, including Hurston, Petry, Morrison, Angelou, and Walker. Levy. (HU)</td>
</tr>
<tr>
<td>AAS 148.</td>
<td>Cultural Diversity in the Caribbean (4) Cultural diversity in the Caribbean islands and the Guyanas, with emphasis on the African, Amerindian, and Indian influences. The sociological and cultural implications of the region's diversity, with special emphasis on ethnicity, slavery and indenture, emancipation and independence, modernization, immigration, the impact of tourism and the development of Creole cultures. Lecture and discussion. Rivera-Martinez. (HU)</td>
</tr>
<tr>
<td>AAS 150.</td>
<td>Africans in the New World (3) African American art, architecture, and craft from pre-colonial Africa to the present. Early primitivism, neo-classicism, the Harlem renaissance, modernism, and contemporary directions. Guest lecturers, open dialogue, gallery visits, and media presentations. Writing Intensive. Boothe. (HU)</td>
</tr>
<tr>
<td>AAS 166.</td>
<td>Who Gets What?: The Social Problems of Wealth and Inequality (3) Considers the existence of poverty amid affluence in the United States. Comparative studies of wealthiest and poorest among us, focusing on social values and social conditions. Sociological and historical analysis through debate on the causes of social problems related to the gap between the “Haves” and “Have-nots.” Washington (SS)</td>
</tr>
<tr>
<td>AAS 263.</td>
<td>Caribbean Artistic and Cultural Traditions (4) Representation of contemporary popular culture in the Caribbean in literature, music, painting and other artistic expressions. Major attention is devoted to the influences on tradition, folklore and religion in modern Caribbean life. Martinez-Rivera. (HU)</td>
</tr>
<tr>
<td>AAS 310.</td>
<td>Gender, Race and Sexuality: The Social Construction of Differences (3) This course will provide the student with an opportunity to engage current debates about the meaning and use of racial and sexual classification systems in society. Using a multidisciplinary and critical approach, we will examine the historical and sociological contexts in which specific theories of racial and sexual differences emerged in the U.S. Prerequisite: SSP 103, or department permission. Washington. (SS)</td>
</tr>
<tr>
<td>AAS 331.</td>
<td>United States and Africa (4) Reciprocal relationships between North America and the African continent from the slave trade in the seventeenth century to the twentieth century Afrocentric movement; impact of Americans on shaping of modern Africa, Pan-African relations; influence of African Americans on U.S. policies toward Africa. Scott. (SS)</td>
</tr>
<tr>
<td>AAS 332.</td>
<td>Slavery and the American South (4) The emergence and demise of the “peculiar institution” of African American slavery in British North America and the Old South. African background, colonial beginnings, 19th century slave community, the ruling race and proslavery ideology, the death of slavery and its aftermath, slavery and freedom in a comparative context. Staff (SS)</td>
</tr>
<tr>
<td>AAS 335.</td>
<td>History of South Africa (4) South Africa’s history from its earliest human settlement to its emergence as a racist political order and transition to a non-racial democratic state. Includes comparisons with political thought and practices in the U.S. Scott. (SS)</td>
</tr>
<tr>
<td>AAS 371, 372</td>
<td>Independent Study (1-3) Independent study in advanced areas of Africana Studies. Independent research with an individual faculty member in the Africana Studies program. Consent of director. (ND)</td>
</tr>
<tr>
<td>AAS 379.</td>
<td>Race and Class in America (3) This course focuses on the ways in which various categories and groupings within the social concepts of “race” and “class” have organized the American social, economic and political structure and shaped national and international policy. An overview of the distribution of wealth and political power in the United States provides the student with the opportunity to consider how and why “race” and “class” both together and separately can be used to explain racism, residential segregation, poverty, working class identity and the existence of a wealthy power elite in the United States. Prerequisite: SSP 103, or department permission.</td>
</tr>
</tbody>
</table>
students choose a concentration from the four areas of history, literature, politics, and society and structures a program that fits their own needs. The courses listed below are recommended, but comparable courses in each of these areas may be substituted with written permission of the director of American Studies. Admission to honors in American Studies is by invitation or request in the student's junior year. The student must attain an average of 3.2 in major courses in addition to the university honors program and complete a four-hour thesis beyond the normal nine course requirement.

required preliminary courses
Choose two from each category

History
Hist 41 United States to 1865
Hist 42 United States, 1865-1941
Hist 43 United States Since 1939
Hist 7 Machine in America

English
Engl 123 American Literature I
Engl 124 American Literature II
Engl 163 Topics in Film Studies
Engl 189 Popular Literature

required American Studies seminar
Choose one
AmSt 111 The American Character
AmSt 311 Themes in Contemporary American Civilization

required upper level courses
Choose a concentration of two courses from one group and an elective of one course from another group.

History
Hist 327 American Intellectual History to 1900
Hist 328 American Intellectual History since 1900
Hist 323 American Cultural History since 1900
Hist 332 Slavery and the American South
Hist 334 American Urban History

English
Engl 376 Early American Literature
Engl 377 American Romanticism
Engl 378 American Realism
Engl 379 Twentieth-Century American Literature
Engl 380 Contemporary American Literature

Political Science
PolS 174 Political Parties and Elections
PolS 217 The American Presidency
PolS 230 Movements and Legacies of the 1960s
PolS 251 Constitutional Law
PolS 252 Civil Rights

Society
SSP 152 Alcohol, Science and Society
SSP 141 Social Deviance and Social Control
SSP 165 Contemporary Social Problems
US 321 White Protestant America

minorities in America
Choose one course from
Engl 316 Native American Literature
PolS 179 The Politics of Women
Hist 124 Women in America
Hist 130 African American History
SSP 103 Racial and Ethnic Communities
These are suggestions; other similar courses (for example: Hist 319, Colonial America or Anth 182, North American Indians) might be used in the concentration or as upper level electives outside the student’s concentration. Because of their cross-listing some courses (for example: Hist/SSP 325. History of Sexuality and the Family in the U.S.) can be used in more than one category although no course may be counted twice.

Courses:

AmSt 311. The American Character (4)
Chronological and methodological analyses of shifting conceptions of the American character. Readings from foreign and domestic observers. Special attention to conceptual difficulties of analyzing national character. (HU)

AmSt 311. Themes in Contemporary American Civilization (4)
A seminar open to juniors and seniors. Subject varies from semester to semester. (HU)

AmSt 317. Special Topics in American Studies (1-4)
Individual study under the direction of a faculty member. May be repeated for credit. Permission of program director required. (HU)

Graduate Work in American Studies
The Master of Arts Program
Candidates for the master's degree must complete at least 30 credit hours. In addition to the Theory and Method course, students must choose two courses in American history and two courses in American literature and film from those offered by the history department and the English department. Students must also take one Special Topics seminar.

The other four courses for the master's degree will be divided between thesis or "thesis paper" credits and American Studies courses not in history or literature/film. To fulfill the thesis requirement, students will write one longer thesis or two thesis papers that are aimed at conference presentation and/or publication.

Graduate Courses in American Studies
AS 400. Theory and Method (3)
Introduction to critical approaches to the interdisciplinary study of American culture. Theories and methods include: the myth and symbol school, Marxism, cultural anthropology, Foucault, deconstruction, race, gender, new historicism, sexuality politics and queer theory, and subaltern studies.

AS 401. Special Topics Seminar in American Studies (3)
Focused interdisciplinary study of one particular subject area in American culture. Course may be repeated with consent of program director.

Anthropology

See listings under Sociology and Anthropology.

Applied Mathematics and Statistics

Professors. Bennett Eisenberg, Ph.D. (M.I.T.); B. K. Ghosh, Ph.D. (London); Samuel L. Gulden, M.A. (Princeton); Wei-Min Huang, Ph.D. (Rochester); George E. McCluskey Jr., Ph.D. (Pennsylvania); Eric P. Salathe, Ph.D. (Brown); Murray Schechter, Ph.D. (N.Y.U.); Gilbert A. Stengle, Ph.D. (Wisconsin) head; Joseph E. Yuki, Ph.D. (M.I.T.).

Associate professors. Garth Isaak, Ph.D. (Rutgers); Ramamirthan Venkataraman, Ph.D. (Brown).

The Division of Applied Mathematics and Statistics was established within the Department of Mathematics to promote and administer undergraduate and graduate education in applied mathematics and statistics, and to foster interdisciplinary research in the mathematical sciences at Lehigh. Courses and programs offered by the division may be found under the departmental listing.

Art and Architecture

Professors. Lucy Gans, M.F.A. (Pratt); Tom F. Peters, M.Arch (ETH Zurich (dipl.Arch.ETH) and Dr.sc. (techn.) ETH Zurich, director, Building and Architectural Technology Institute; Ricardo Viera, M.F.A. (R.I.S.D.), director of Lehigh University Art Galleries; Ivan Zaknic, M. Arch. and Urban Planning (Princeton).

Associate professors. Berrisford W. Boothe, M.F.A. (Maryland Institute College of Art); Bruce Thomas, Ph.D. (University of California, Berkeley) Chair; Anthony Viscardi, M.Arch (Georgia Institute of Technology).

Lecturer. Christine Ussler, M.Arch (Columbia University).

Adjunct assistant professors. Ann Priest, Ph.D. (Princeton); Myron Barnstone, C.F.A. (Ruskin School of Drawing, Oxford).

Adjunct lecturers. Anthony Corallo, M.Arch (University of Pennsylvania); Douglas Mason, B.F.A. (R.I.S.D)

The department of art and architecture offers two major programs:

The architecture major is a multidisciplinary major based in a department that draws on the resources of all Lehigh's colleges. Although architectural design is the primary concern of this major, other courses in architectural history, art studio and technology are also required. A special track is available within the architecture major for students interested in architectural history.

The architecture major leads to the liberal arts B.A. (Bachelor of Arts), a four-year degree. This degree is satisfactory for admission to graduate study in architecture and candidacy for the M.Arch. professional degree.

In recent years students have gone on to graduate study in architecture at Yale, Harvard, Columbia, University of Pennsylvania, Maryland and Washington University, among other schools, or to entry-level employment in the profession.

Double majors in urban studies are quite frequent and the Arts/Engineering five-year degree, in which the student earns both B.A. (architecture) and B.S. (civil engineering), is available for those interested in both fields.

A major in art introduces the student to the basic media of art such as drawing, sculpture, printmaking, painting, and photography. For those interested in becoming creative artists, intensive study at Lehigh as well as the other Lehigh Valley colleges is recommended; such students can expect to take more than the required number of credits for the major. Cooperation with Moravian College allows students to register for art courses not offered at Lehigh, such as ceramics.

A major in art may also be combined with a series of linked, interdisciplinary courses known as Integrated Product Design (IPD), focusing on industrial products.

A major in art can also be combined with psychology for those who seek a career in art therapy. It may also be combined with theater for those interested in costume design or with architecture and theater for those interested in set design. A major in art and minor in education is available for students interested in becoming public school art teachers. A special track is available within the art major for students interested in art history.

The resources of the Lehigh University art collection are made available to many students taking classes in art. Prints, photographs, and paintings are often brought into the classroom and visits to art exhibitions on campus and elsewhere in the Lehigh Valley are a common part of art instruction.
The facilities of the Lehigh University Art Galleries make it possible to see first-rate works of art on a regular basis. The annual contemporary art show is a special event. Several major museums are within easy traveling distance and the department runs regular bus trips to New York City. An annual lecture series brings architects and artists to campus. In recent years Rodolfo Machado, Charles Gwathmey, Klaus Herdeg, Edmund Bacon, Steven Peterson, Tod Williams, Peter Eisenman, Thomas Armstrong, Rev. Howard Finster, Joyce Kozloff, Jonas Dos Santos, Geno Rodriguez, Harold Edgerton, Peter Berg and Jody Pinto have come to Lehigh.

In addition to these two major programs, individually structured programs may be planned, such as art with an emphasis on architectural design, art history with an emphasis on museum training, and architecture with an emphasis on planning, urban studies, graphic communication, or government. Minor programs have been established in architecture, art, studio art, art/architectural history, graphic communication, and museum studies. Course requirements are specified, and a list of courses acceptable for the minors is available in the department.

Note: A student must achieve a 2.0 or higher in each major course.

**Departmental Honors:**

Exceptional students in art or architecture may apply for departmental honors at the end of their junior year or beginning of their senior year. To be eligible, a student must have attained a 3.5 GPA in her/his major program and a minimum overall GPA of 3.0. Candidates should submit to the department chair a written proposal, prepared in consultation with a faculty advisor. The project could result in a research paper, design project, or exhibition, accompanied by an oral presentation. Successful completion of the project and presentation would result in the “Departmental Honors” designation being affixed to the student’s transcript.

**Art Major**

Forty-three credit hours are required.

**Required courses (22 credit hours)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Art 1 or Arch 1</td>
<td>Art History I or Architectural History I (3)</td>
</tr>
<tr>
<td>Art 2</td>
<td>Art History II (3)</td>
</tr>
<tr>
<td>Art 7</td>
<td>Basic Design (3)</td>
</tr>
<tr>
<td>Art 8</td>
<td>Foundation in Drawing and Design (4)</td>
</tr>
<tr>
<td>Art 13</td>
<td>Sculpture I (3)</td>
</tr>
<tr>
<td>Art 15</td>
<td>Figure I (3)</td>
</tr>
<tr>
<td>Art 220</td>
<td>20th-Century Art (3)</td>
</tr>
</tbody>
</table>

**plus one of the following (3 credit hours)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Art 82</td>
<td>Art and Archaeology of Greece (3)</td>
</tr>
<tr>
<td>Art 121 / WS 121</td>
<td>Women in Art (3)</td>
</tr>
<tr>
<td>Art 150 / AAS 150</td>
<td>Africans in the New World (3)</td>
</tr>
<tr>
<td>Art 175</td>
<td>Introduction to Museum Work (3)</td>
</tr>
<tr>
<td>Art 206 / Arch 206</td>
<td>Medieval Art and Architecture (3)</td>
</tr>
<tr>
<td>Art 207 / Arch 207</td>
<td>Renaissance Art and Architecture (3)</td>
</tr>
<tr>
<td>Arch 210</td>
<td>20th-Century Architecture (3)</td>
</tr>
<tr>
<td>Arch 222</td>
<td>Seminar in Contemporary Art (3)</td>
</tr>
</tbody>
</table>

**plus six studio major courses (18 credit hours)**

Art studio; six courses, two at the advanced level

Students who desire an art history concentration are required to take Art 1 or Arch 1 and Art 2, Art 7, Art 8, Art 220 plus one other studio. At least six courses in the history or philosophy of art and/or architecture must be selected in consultation with the instructor.

Students selecting a graphic communication concentration are required to take Art 7 and Art 8 before completing the graphic communication sequence. Other recommended courses may be selected in consultation with the instructor.

**Architecture Major**

Fifty credit hours are required.

**Design Sequence (22 credit hours)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arch 43</td>
<td>Architectural Design I (4)</td>
</tr>
<tr>
<td>Arch 143</td>
<td>Architectural Design II (6)</td>
</tr>
<tr>
<td>Arch 243</td>
<td>Architectural Design III (6)</td>
</tr>
<tr>
<td>Arch 343</td>
<td>Architectural Design IV (6)</td>
</tr>
</tbody>
</table>

**Art Studio (10 credit hours)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Art 8</td>
<td>Foundation in Drawing and Design (4)</td>
</tr>
<tr>
<td>plus two other studios (various choices) (6)</td>
<td></td>
</tr>
</tbody>
</table>

**Architectural History (9 credit hours)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Art 1 or Arch 1</td>
<td>Art History I or Architectural History I (3)</td>
</tr>
<tr>
<td>Arch 2</td>
<td>Architectural History II (3)</td>
</tr>
<tr>
<td>Arch 210</td>
<td>20th Century Architecture (3)</td>
</tr>
</tbody>
</table>

**Architecture and its intellectual context (9 credit hours)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arch 107</td>
<td>History of American Architecture (3)</td>
</tr>
<tr>
<td>Arch 204</td>
<td>Ancient City and Society (3)</td>
</tr>
<tr>
<td>Arch 206 / Arch 207</td>
<td>Medieval Art and Architecture (3)</td>
</tr>
<tr>
<td>Arch 207 / Arch 207</td>
<td>Renaissance Art and Architecture (3)</td>
</tr>
<tr>
<td>Arch 209</td>
<td>Architecture and Ideas (3)</td>
</tr>
<tr>
<td>Arch 213</td>
<td>The City (3)</td>
</tr>
<tr>
<td>Arch 223</td>
<td>The Architecture of Charles Scarpa/Theory and Practice (3)</td>
</tr>
<tr>
<td>Arch 253</td>
<td>Paris, The Planning of a Metropolis (3)</td>
</tr>
<tr>
<td>Arch 254</td>
<td>Modern Architecture in France: New Directions (3)</td>
</tr>
<tr>
<td>Arch 342</td>
<td>Theory of Architecture (3)</td>
</tr>
<tr>
<td>Arch 367</td>
<td>Modernism to Post-Modernism (3)</td>
</tr>
<tr>
<td>Arch 418</td>
<td>Urban Ethnology (3)</td>
</tr>
<tr>
<td>Arch 335</td>
<td>Religion, Symbolism and Cosmology (3)</td>
</tr>
<tr>
<td>Eco 311</td>
<td>Environmental Economics (3)</td>
</tr>
<tr>
<td>Eco 312</td>
<td>Urban Economics (3)</td>
</tr>
<tr>
<td>Hist 334</td>
<td>American Urban History (4)</td>
</tr>
<tr>
<td>Phil 123</td>
<td>Aesthetics (3)</td>
</tr>
<tr>
<td>Psy 373</td>
<td>Sensation and Perception (4)</td>
</tr>
<tr>
<td>US 524</td>
<td>Contemporary Urban Issues (4)</td>
</tr>
<tr>
<td>US 363</td>
<td>Philadelphia: Development of a Metropolis (4)</td>
</tr>
</tbody>
</table>

**Architecture and Technology**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arch 147</td>
<td>Building Materials and Methods (3)</td>
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<tr>
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For the architecture major, students must fulfill the mathematics requirement with Math 21 & 22 or Math 51 & 52; the physical science requirement must be filled with Phys 11 & 12.

For students contemplating graduate studies in architecture, Mech 2 is recommended.

**Undergraduate Courses in Art**

**Art 1. Art History: Ancient and Medieval (3)**

Survey of major monuments of art and architecture from the prehistoric caves of Lascaux and Altamira through the Gothic cathedrals of Chartres and Notre-Dame of Paris, along with highlights of art and architecture of the non-Western civilizations of Africa, India, and China. Work seen in the context of cultural, historical, and technological developments. Priest. (HU)

**Art 2. Art History: Renaissance to Present (3)**

Survey of Western painting and sculpture from the prehistoric caves of Lascaux and Altamira through the Gothic cathedrals of Chartres and Notre-Dame of Paris, along with highlights of art and architecture of the non-Western civilizations of Africa, India, and China. Work seen in the context of cultural, historical, and technological developments. Priest. (HU)
Art 7. Basic Design (3) fall-spring
Form and space as foundation for design. Principles and practice of visual expression using line, color, space, mass, value, and texture. Staff. (HU)

Art 8. Foundation in Drawing and Design (4) fall-spring
Introduction to the heritage of design systems underlying classical drawing. Analytical methods of design such as the Golden Section. This course must be taken in sequence for Architecture and Graphic Communication. Barnstone. (HU)

Art 11. Drawing I (3) Concepts and practice of drawing, both traditional and contemporary. Includes drawing from life and an introduction to materials and techniques. Staff. (HU)

Art 13. Sculpture I (3) Projects directed toward developing design in sculpture. Exploration of materials and their application. Emphasis on sculptural form as it relates to techniques. Gans. (HU)

Art 15. Figure I (3) Drawing and modeling in clay from direct observation of the human figure. Fundamental principles of drawing, and two- and three-dimensional design through analysis of the human form. In-class exercises cover basic scale, proportion, structure, drawing media and techniques, and clay modeling. Emphasis on personal expression, the human figure as vehicle for narrative, abstract or formal drawings or sculpture. Gans. (HU)

Art 37. Survey of Printmaking I (3) fall
Introduction to various techniques in relief and intaglio printing: monoprints, woodcuts, linocuts, drypoint, etching grounds, aquatint, and other intaglio techniques. Includes an historical survey through slides and actual examples. Viera. (HU)

Art 38. Survey of Printmaking II (3) spring
Introduction to the fundamentals of stone and metal lithography and the basics of screen printing as a fine art print medium: various screen stencils, blockouts, and color transparencies; drawing methods and transfer. Includes an historical survey through slides and actual examples. Viera (HU)

Art 53. Graphic Communication I (3) fall
Design principles are explored with emphasis on visual communication. Students learn basic concepts for design and typography including the vocabulary and historical precedence of graphic design and computer graphics. Introduction to professional-level formal exercises contributes to the development of visual thinking and original ideas. Prerequisite: Art 7 or Art 8. Staff. (HU)

Art 77. Photography I (3)
Introduction to photography as a fine art. Emphasis on interaction of technique, perception and communication in making and responding to photographic image. Lectures, demonstrations, critiques. Students must provide own hand camera. Mason. (HU)

Art 82. Art and Archaeology of Greece (3)
The art and architecture of ancient Greece as revealed by archaeology. Brief surveys of the political and cultural backgrounds to the various artistic periods: Bronze Age, Geometric, Orientalizing, Classical, Hellenistic and Roman. Lectures, slides and films. (SS)

Art 111. Drawing II (3) Projects in creative drawing designed to build on concepts and practices initiated in basic drawing and life drawing. Prerequisite: Art 8 or Art 11. Staff. (HU)

Art 113. Sculpture II (3)

Art 115. Figure II (3) Projects in figure modeling and drawing from direct observation of the human figure, designed to build on concepts and practices initiated in Figure I. Students may elect to concentrate in one particular medium, although the primary investigation of form will always incorporate both two- and three-dimensional work. Prerequisite: Art 15. Gans. (HU)

Art 121. (WS 121) Women in Art (3)
Women artists from Renaissance to present. Attitudes toward women artists and their work; changing role of women in the art world. Visits to museums and artists' studios. May be repeated for credit as topic varies. Gans. (HU)

Art 135. Painting I (3) Painting in oil or acrylic oriented toward developing individual creative expression combined with an understanding of the physical nature of the materials. Studio prerequisite: Art 7, 8 or 11, or consent of instructor. Boothe. (HU)

Art 150. (AAS 150) Africans in the New World (3) spring
African American art, architecture, and craft from pre-colonial Africa to the present. Early primitivism, neo-classicism, the Harlem renaissance, modernism, and contemporary directions. Guest lecturers, open dialogue, gallery visits, and media presentations. Writing intensive. Boothe. (HU)

Art 153. Graphic Communication II (3) spring
Aspects of design are inter-related in function, concept or planning processes. Students focus on the poster in order to solve a variety of contemporary design problems. Professional-level formal team exercises include a series of informative posters, identity systems, publication, and advertising design. Computer graphics and Macintosh lab are employed as integral design tools in graphic design. Prerequisite: Art 53. Viera. (HU)

Art 174. (Arch 174, Clss 174, Anth 174) Greek Archaeology (3)
Ancient Greek cultures from the neolithic to Hellenistic periods. Reconstructions of Greek social dynamics from study of artifacts. Small. (SS)

Art 176. (Arch 176, Clss 176, Anth 176) Roman Archaeology (3)
Cultures of the Roman Empire. Reconstructions of social, political, and economic dynamics of the imperial system from study of artifacts. Small. (SS)

Art 177. Photography II (3) Intensive work in photography as fine art. Advanced study of problems of the photographic images. Lectures, demonstrations, critiques. Students must provide own hand camera. Prerequisite: Art 77. Mason. (HU)

Art 179. History of Photography (1)
Photography as fine art from earliest images to present day. Problems in contemporary photography. Mason. (HU)

Art 206. (Arch 206) Medieval Art and Architecture (3)
Focus on art and architecture in Western Europe from 313 A.D. until ca. 1500 A.D. Topics include: the emergence of Christian art and architecture; the art of barbarian migrations; the Carolingian Renaissance; monasticism, pilgrimage and the Romanesque; the Gothic cathedral; and medieval manuscript illumination. Priester. (HU)
Art 207. (Arch 207) Renaissance Art and Architecture (3)
Survey of the art and architecture of the Italian Renaissance from its beginnings in 13th and 14th century Tuscany and its first flowering in 15th century Florence through the brilliant achievements of the masters of the High Renaissance and later 16th century. Priester. (HU)

Art 211. Drawing III (3)
Projects in traditional and contemporary drawing. Oriented toward developing an individual portfolio. Drawing as a vehicle for ideas, creative expression, and image making. Students investigate a broad range of materials, forms and traditions. Prerequisite: Art 111. Booth or Gans. (HU)

Art 215. Figure III (3)
Further exploration of the human figure as the subject of art. More advanced students may elect to concentrate in either two- or three-dimensional representations in any media. The emphasis will be on personal interpretation and independent work with the instructor. Prerequisite: Art 115. Gans (HU)

Art 220. 20th-Century Art (3)
A survey of the major movements of 20th century art including Cubism, Expressionism, Surrealism, Abstract Expressionism, Pop, Minimalism, Conceptual Art, Feminism and Post-Modernism. Priester. (HU)

Art 222. Seminar in Contemporary Art (3)
Recent aspects, developments in contemporary art. Exploring ideas and consequences of today's image-making. Studio workshops, readings, discussions and museum visits. Prerequisite: Art 2. Staff. (HU)

Art 235. Painting II (3)
Problems in oil, watercolor, acrylic and mixed media. Prerequisite: Art 135. Booth. (HU)

Art 252. Advanced Studio Practice (3)
Advanced studio for art or architecture majors under guidance of faculty. Oral and written critiques. Variable media. May be repeated for credit. Prerequisites: Art 7, 11, 37, 135 or consent of instructor. Staff. (ND)

Art 253. Graphic Communication III (3)
A combination workshop/seminar course in which the student, as part of a design team, through classroom and individual discussion with the instructor and respective non-profit clients, develops and produces a minimum of two major design projects. Readings and classroom discussions of contemporary graphic design history and current trends form an essential part of the course. Prerequisite: Art 153. Viera. (HU)

Art 269. Special Topics in Art History (1-3)
Directed projects for advanced students in the history of art or architecture. Prerequisite: consent of instructor. May be repeated for credit. Staff. (ND)

Art 273. Special Topics in Studio Practice (1-4)
Individually directed projects for advanced students capable of undertaking independent creative work in studio art. Prerequisite: consent of instructor. May be repeated for credit. Staff. (ND)

Art 277. Special Topics in Photography (1-4)
Individually directed projects in photography for advanced students capable of undertaking creative work in photography. Prerequisites: Art 77, 177 and consent of instructor. May be repeated for credit. Mason. (ND)

Art 335. Painting III (3)
Prerequisite: Art 235 or consent of instructor. May be repeated for credit. Staff. (HU)

Art 337. Printmaking Workshop (3) spring
A workshop in printmaking emphasizing individual instruction, and allowing students to explore the mediums of relief, intaglio, lithography, screen printing, and/or combinations while developing a relationship between the print and their other work. May be repeated for credit. Prerequisite: Art 37 and Art 38. Viera. (HU)

Art 350. Special Topics in Graphic Communication (1-4)
Independent study for graduate and advanced undergraduates in intermediate and advanced graphic communication course work in the Art 53, 153, 253, and 353 sequence. May be repeated for credit. Staff. (ND)

Art 353. Graphic Communication Internship (1-4)
Practical in-field experience in a communication design field. Pre-approved a semester in advance by instructor and host organization. A minimum of 15 hours per week. Prerequisite: Art 253. Viera. (ND)

Art 373. Studio Art Internship (1-4)
Practical in-field experience in an artist's studio or art-related apprenticeship opportunity. Requires approval a semester in advance by instructor and host organization. Staff. (ND)

Undergraduate Courses in Architecture
Arch 1. Architectural History I (3) fall
Survey of architecture from earliest building to the Renaissance, examined in the context of culture formation, design concepts, and the built environment. Slide lectures. Thomas. (HU)

Arch 2. Architectural History II (3) spring
Survey of architecture from the Renaissance to the present, examined in the context of culture formation, design concepts, and the built environment. Thomas. (HU)

Arch. 43. Architectural Design I (4)
Fundamental design studio for architecture majors. Composition, spatial concepts; precedent; materials and detail; light and color in architecture. Instruction in basic communication techniques. Prerequisite: Art 7 or Art 8. Viscardi or Ussler. (ND)

Arch 103. Archaeology of Italy (3)
Neolithic, Terramara, Villanovan and Etruscan cultures. Rome the city: its buildings, monuments and streets, through the kingdom, republic, and empire. Survey of Pompeii, Herculaneum and Ostia. Lectures, readings and reports. (SS)

Arch 107. History of American Architecture (3) spring
Survey of American building from European colonization to the present. Prerequisite: Art 1/Arch 1 and Arch 2 or permission of instructor. Thomas. (HU)

Arch 143. Architectural Design II (6)
Studio format, introductory course in architectural design which introduces students to new ways of thinking about architecture and the perception of space, three-dimensional composition, drawing, and model-making. Previous or concurrent courses in studio art and/or architectural history are recommended. Prerequisite: Art 8 and Arch 43. Zaknic, Corallo. (ND)

Arch 147. Building Materials and Methods (3)
The primary structural material block, wood, steel and reinforced concrete are examined in their relationship to architectural design. Peters. (ND)

Arch 161. (Thtr 161) Theatre Design and Technology (4)
Theatre environments, equipment systems and acoustics. Functions and ethics. (HU)
Arch 174. (Art 174, Cls 174, Anth 174) Greek Archaeology (3)
Ancient Greek cultures from the neolithic to hellenistic periods.
Reconstructions of Greek social dynamics from study of artifacts.
Small. (SS)

Arch 176. (Art 176, Cls 176, Anth 176) Roman Archaeology (3)
Cultures of the Roman Empire: Reconstructions of social,
political, and economic dynamics of the imperial system from
study of artifacts. Small. (SS)

Arch 204. (Clss 204) Ancient City and Society (3)
Ancient theories of city and city planning: attitudes to life in the
city; rise of urban civilization from Neolithic prototypes through
the Near East, Egypt, Greece, Rome, and New World; insights
applicable to current urban problems. (SS)

Arch 206. (Art 206) Medieval Art and Architecture (3)
Focus on art and architecture in Western Europe from 313 A.D.
until ca. 1500 A.D. Topics include: the emergence of Christian art
and architecture; the art of barbarian migrations; the Carolingian
Renaissance; monasticism, pilgrimage and the Romanesque; the
Gothic cathedral; and medieval manuscript illumination. Priester.
(HU)

Arch 207. (Art 207) Renaissance Art and Architecture (3)
Survey of the art and architecture of the Italian Renaissance from
its beginnings in 13th and 14th century Tuscany and its first
flowering in 15th century Florence through the brilliant
achievements of the masters of the High Renaissance and later
16th century. Priester. (HU)

Arch 209. Architecture and Ideas (3)
Examination of philosophical, technological, and cultural forces
shaping Western architecture and urbanism. Prerequisites: Art/
Arch 1 and Arch 2 or permission of instructor. Writing intensive.
Thomas. (HU)

Arch 210. 20th-Century Architecture (3)
History and theory of modern architecture. Analysis of buildings
and architects, theories and manifestoes, from industrial
revolution to avant-garde movements. Prerequisite: Art 1 or
Arch 1 and another course in architectural history is
recommended. Zaknic. (HU)

Arch 213. The City (3)
Historical development of the modern city. Philosophical,
technological, and cultural forces shaping urban experience.
Western culture beginning with the Enlightenment.
Prerequisites: Art 1 or Arch 1 and Arch 2 or permission of
instructor. Thomas. (HU)

Arch 223. The Architecture of Carlos Scarpa/Theory and
Practice (3) alternate summers in Italy
This course which is part of the Lehigh in Italy summer program
will survey several of the Venetian architect’s most famous
works. Meet with architects who worked with Scarpa and
completed his unfinished projects. Explore thematic principles
behind Scarpa’s work, their origin and role in his unique process
of design. Viscardi. (HU)

Arch 235. Architectural Drawing/Analysis and Expressions (3)
alternate summers in Italy
This studio course is part of the Lehigh in Italy summer program
and will utilize several different architectural drawing
techniques to study aspects of architecture from analysis of
a piazza to architecture in detail. It will employ pencil sketching,
charcoal drawing, and water color. These drawings will act as a
way of seeing the Italian urban landscape and supplement the
study and analysis of the Italian architects’ contemporary work.
Viscardi. (ND)

Arch 243. Architectural Design III (6)
Continuation of Arch 143. Design principles of space and form
stressed in earlier studios to issues of “materiality,” “structure,”
“modes of representation” and the “process of making.”
Prerequisites: Arch 1, 43, 143 and one art studio. Viscardi. (ND)

Arch 253. Paris, the Planning of a Metropolis (3)
alternate summers in Paris
The splendor of modern Paris is due in large part to bold,
large-scale modernization and changes in the city’s patterns during the 19th
century. This course, which is part of the Lehigh in Paris summer
program, will cover a century of change and focus on the major
accomplishments of its visionary planners. Zaknic (HU)

Arch 254. Modern Architecture in France: New Directions (3)
alternate summers in Paris
The course, which is part of the Lehigh in Paris summer
program, will cover the most important contributions to modern
architecture in the Paris region including Centre Pompidou, Musee
der Orsay, LeGrand Louvre, Parc de la Villette, La Defense, and the
new satellite towns around Paris. Zaknic (HU)

Arch 271. Special Topics in Architecture (1-4)
Directed projects for advanced students in architecture or
architectural criticism. Prerequisites: Arch 1, 143, Art 8. Major
standing in the department or consent of instructor. Student
must contact sponsoring professor and complete a contract sheet
at pre-registration. May be repeated for credit. Staff. (ND)

Arch 311. Portfolio (1)
The concept, layout, and preparation of a portfolio for graduate
school application or employment search, including graphic
techniques and reproduction method. Student must contact
sponsoring professor. Prerequisite: Arch 243. Staff. (ND)

Arch 321. Architectural Internship (1-3)
Supervised internship in architectural firm, planning or
preservation office. Internship plan must be approved in writing
before it is pursued. Staff. (ND)

Arch 328. Architectural Representation (3)
Studio format, instruction in rendering media such as graphite,
charcoal, color pencil, water color and pastel and a variety of
three-dimensional drawing techniques. Intended for
architectural students who have mastered orthographic drawing
(plan, elevation, section). The origin, history, and theory of
three-dimensional drawing techniques will also be studied.
Prerequisite: Arch 243. Ussler. (ND)

Arch 342. Theory of Architecture (3)
Study of the genesis of form, its representation and its
interrelationship to related artistic disciplines. Formal notions will
be studied, compared and manipulated through the role of time,
scale, perceptual analysis and material transformation.
Permission of instructor required. Viscardi. (ND)

Arch 343. Architectural Design IV (6)
Continuation of Arch 243. The design of buildings and building
groups, with the emphasis on urban design and the city.
Prerequisite: Arch 1, 43, 143, 210, 243 and one art studio. Ussler.
(ND)

Arch 345. Architectural Design V (3)
Undergraduate thesis. An individual design project exploring,
with faculty approval, some aspect of architecture of interest to
the student. Prerequisite: Architectural Design I-IV; all other
courses required for major, previously or concurrently. Staff.
(ND)
The criteria of trade-time and money entered the world of trade. The new materials—iron and concrete—led to new ways of thinking about building. The Industrial Revolution initiated the development of our modern culture of building and our current urban society. Peters. (HU)

Arch 367. Modernism to Postmodernism (3)
Re-examine the central issues facing the great masters of twentieth-century architecture: how they formulated their principles, how they applied them, and how those who inherited the legacy have interpreted it. The major attention will focus on either the great master builders such as Le Corbusier, Mies van der Rohe, Frank Lloyd Wright and Walter Gropius, or on second generation including the transitional figures such as Philip Johnson and other groups: The Whites, Greys, High-Tech, etc. Prerequisite: Art I / Arch I or Art 2 / Arch 2 and Arch 210. Zaknic. (HU)

Arch 388. Advanced Architectural Design (3) spring
Intensive design projects under a sequence of visiting design instructors. Prerequisites: Arch 210, 243 and consent of instructor. Zaknic. (ND)

Museum Studies
Art 175. Introduction to Museum Work (3) fall
Introduction to the methods and procedures of research and interpretation of art objects, historical material sites, documents, specimens, and living entities. The nature of museum work in its practical aspects. Field trips and workshops. Each student completes several interactive projects. Viera. (ND)

Art 275. Museography and Museology (3) fall-spring
Theory and practice in contemporary museums and galleries. Practicum in the L.U.A.G. Museum operation, dealing with collection management, exhibition, and interpretation issues. Student completes a research report or equivalent. Recommend that concentration/minors repeat this course. Prerequisite: Art 175. Viera. (ND)

Art 370. Special Topics in Museum Studies (1-4)
Special project and/or internship for graduate and advanced undergraduates in the museum studies sequence: Art 175, 275, 375. Viera (ND)

Art 375. Museum Internship (3) fall-spring
Internship under professional supervision in one or more of the following areas: education/interpretation, collection management, curatorial, exhibition/installation, and development/PR, administration; in one of the following regional organizations: Allentown Art Museum, Lehigh County Historical Society, Kemmerer Museum of Decorative Art, Hugh Moore Park, Canal Museum. Prerequisite: Art 275. Viera. (ND)

Arts and Sciences

Arts 1-9. Choices and Decisions (1)
Introduction to decision making with emphasis on curriculum, career planning, and social options. Techniques for using values, family history, and social norms as guidelines for decision-making processes. Pass-fail grading.

Arts 250. Interpersonal Development in a Changing Society (3)
Writing-intensive experiential focus on development of social roles required for effective functioning in a diverse American society. Models of interpersonal communication in groups; cognitive processes in handling individual differences in race, gender, class, sexual orientation and culture in traditional American institutions; synthesis of class experiences with readings; social role implications of personal choices. Prerequisite: permission of instructors. A team-taught course. Students may not receive credit for both Arts 250 and Comm 65 (or Comm 95). (ND)

Arts-Engineering

The Arts-Engineering program provides the student with an opportunity to experience the breadth of an arts education and simultaneously follow the more focused curriculum of an engineering major. This is a five-year, dual-degree program administered by the College of Arts and Sciences. An Arts-Engineering graduate is awarded two bachelors degrees, one from the College of Arts and Sciences and another from the College of Engineering and Applied Science.

A typical freshman year class schedule for an Arts-Engineer is shown below.

**freshman year, first semester** (16 credit hours)
- **Arts 2** Choices & Decisions I(P/F)
- **Engl 1** Composition/Literature 3
- **Math 21** Calculus 4
- **Chm 21** Intro Chemical Principles 4
- **Chm 22** Intro Chem Princ Lab 1
- **(Dept) 90** College Seminar 3

**freshman year, second semester** (16 credit hours)
- **Engl** to be selected 3
- **Math 22** Calculus II 4
- **Phy 11** Intro Physics I 4
- **Phy 12** Intro Physics Lab I 1
- **Engr 1** Engineering Computations 3
- **Engr 2** Intro to Engineering I(P/F)

Selection of a major in the College of Engineering and Applied Science occurs prior to beginning the sophomore year. A major leading to a degree in the College of Arts and Sciences should be chosen prior to beginning the junior year.

Basic Arts-Engineering programs leading to a bachelor of arts degree from the College of Arts and Sciences and a Bachelor of Science degree in an area of engineering are suggested below. The listed courses may be taken in any order if prerequisites are met. Arts-Engineering candidates should recognize that pursuit
of a bachelor of science degree (e.g., biology, chemistry, biochemistry, earth and environmental sciences, mathematics, and physics) or a bachelor of arts program with larger than average credit requirements (e.g., art, architecture, physical sciences, cognitive science, international careers, among others) will severely restrict choices of free electives. For these students, very careful planning of the academic program is necessary to guarantee completion of all major, distribution and total credit requirements for the two degrees in five years.

The designation AS-courses/electives refers to those courses which meet the major and distribution requirements for the degree in the College of Arts and Sciences. When selected properly, courses which meet distribution requirements in the College of Arts and Sciences will also satisfy most distribution requirements of the College of Engineering and Applied Science.

Arts-Chemical Engineering

The requirements for the bachelor of arts and the bachelor of science degree in chemical engineering must be met and usually the range of credit hours is 164-170 depending on the selection of electives.

See electives (1) through (5) for the chemical engineering program in Section III. Careful planning is required so that these may be scheduled during the senior year and fifth year of the program. Any order that does not violate prerequisites is acceptable.

**fifth year**

See program description for senior year of Chemical Engineering.

*These electives are chosen with the chemical engineering adviser.

**Arts-Civil Engineering**

A total of 163 credit hours is needed for the bachelor of arts and the bachelor of science degrees.

**sophomore year, first semester (16 credit hours)**

Math 23 Calculus III (4)
Mech 2 Elementary Engineering Mechanics (3)
EES 101 Geology for Engineers (3)
AS courses/electives (6)

**sophomore year, second semester (17 credit hours)**

Math 205 Linear Methods (3)
Mech 12 Strength of Materials (3)
Phy 21 Introductory Physics II (4)
Phy 22 Introductory Physics Lab II (1)
CE 15 Graphics for Civil Engineering (3)
AS course/elective (3)

**junior year, first semester (16 credit hours)**

Mat 192 Structural Materials (3)
CE 14 Measurements and Problem Solving in Civil Engineering (4)
CE 121 Mechanics of Fluids (3)
Eco 1 Principles of Economics (4)
AS courses/electives (6)

**junior year, second semester (17 credit hours)**

CE 117 Numerical Methods in Civil Engineering (2)
CE 222 Hydraulic Engineering (4)
Eco 1 Principles of Economics (4)
AS courses/electives (6)

**senior year, first semester (17 credit hours)**

CE 143 Soil Mechanics (4)
CE 159 Structural Analysis I (4)
AS courses/electives (9)

**senior year, second semester (17 credit hours)**

CE 160 Structural Design (4)
CE 270 Introduction to Environmental Engineering (4)
AS courses/electives (9)

**fifth year, first semester (17 credit hours)**

CE 202 Civil Engineering Planning and Engineering Economics (3)
CE 203 Professional Development (2)
Civil Engineering electives** (6)
AS courses/electives (6)

**fifth year, second semester (15 credit hours)**

CE 207 Transportation Engineering (3)
CE 290 Civil Engineering Design Project (3)
Civil Engineering elective** (3)
AS courses/electives (6)

*Mech 102, ME 104, or ECE 81

**Elective that requires approval of the Civil Engineering Department Chairperson.

**Arts-Computer Engineering**

A total of 167 credit hours is needed for the bachelor of arts and the bachelor of science degrees.
sophomore year, first semester (16 credit hours)
Math 23 Calculus III (4)
Phy 21 Introductory Physics II (4)
Phy 22 Introductory Physics Lab II (1)
ECE 33 Introduction to Computer Engineering (4) AS course/elective (3)

sophomore year, second semester (17 credit hours)
CSc 17 Structured Programming and Data Structures (4)
Math 205 Linear Methods (3)
Eco 1 Principles of Economics (4) AS courses/electives (5)

junior year, first semester (16 credit hours)
ECE 81 Principles of Electrical Engineering (4)
Math 231 Probability and Statistics (3) or Math 309 Theory of Probability (3) AS courses/electives (9)

junior year, second semester (17 credit hours)
ECE 82 Sophomore Laboratory (1)
ECE 108 Signals and Systems (4) AS courses/electives (12)

senior year, first semester (17 credit hours)
ECE 121 Electronic Circuits Laboratory (2)
ECE 123 Electronic Circuits (3)
CSc 262 Programming Languages (3) approved technical elective* (3) AS courses/electives (6)

senior year, second semester (16 credit hours)
ECE 138 Digital Systems Laboratory (2)
ECE 201 Computer Architecture (3)
ECE 216 Software Engineering (3)
CSc 261 Discrete Structures (3) AS courses/electives (5)

fifth year (36 credit hours)
See program description for senior year of computer engineering.

*Approved technical electives, chosen with the advisor’s consent, are subjects in the area of science and technology. They are not restricted to offerings in the department of computer science and electrical engineering. One elective must be an engineering science elective from another department.

Arts-Electrical Engineering
A total of 166 credit hours is needed for the bachelor of arts and bachelor of science degrees.

sophomore year, first semester (15 credit hours)
Math 23 Calculus III (4)
Phy 21 Introductory Physics II (4)
Phy 22 Introductory Physics Lab II (1) AS courses/electives (6)

sophomore year, second semester (15 credit hours)
Math 205 Linear Methods (3) approved elective* (3) AS courses/electives (9)

junior year, first semester (17 credit hours)
ECE 33 Introduction to Computer Engineering (4)
ECE 81 Principles of Electrical Engineering (4)
Math 208 Complex Variables (3) AS courses/electives (6)

junior year, second semester (17 credit hours)
ECE 82 Sophomore Laboratory (1)
ECE 108 Signals and Systems (4) AS courses/electives (6)

senior year, first semester (18 credit hours)
ECE 121 Electronic Circuits Laboratory (2)
ECE 123 Electronic Circuits (3)
ECE 202 Introduction to Electromagnetics (3)
Eco 1 Principles of Economics (4) approved elective* (3) AS courses/electives (3)

senior year, second semester (16 credit hours)
ECE 125 Circuits and Systems (3)
ECE 138 Digital Systems Laboratory (2)
ECE 203 Introduction to Electromagnetic Waves (3) approved technical elective* (3) AS courses/electives (5)

fifth year (36 credit hours)
See program description for senior year of electrical engineering, under Electrical Engineering and Computer Science.

*Approved technical electives, chosen with the advisor’s consent, are listed in the catalog after the description of the Bachelor of Electrical Engineering degree. Students must select a minimum of four courses from that listing, with a minimum of two courses in each of two technical areas described in the list. Students must also choose at least one science elective in physics, chemistry or biology. For students interested in solid state electronics, quantum mechanics is recommended for the science elective.

Arts-Engineering Physics
A total of 161 credit hours is needed for the bachelor of arts and bachelor degrees.

sophomore year, first semester (17 credit hours)
Phy 21 Introductory Physics II (4)
Phy 22 Introductory Physics Lab II (1)
Math 23 Calculus III (4)
Eco 1 Principles of Economics (4)
ECE 81 Principles of Electrical Engineering (4)

sophomore year, second semester (16 credit hours)
Phy 31 Introduction to Quantum Mechanics (3)
Phy 190 Electronics (3)
Math 205 Linear Methods (3)
Math 208 Complex Variables (3)
ECE 108 Signals and Systems (4)

The student must choose either the Solid State Electronics or the Optical Sciences concentration, listed below.

Solid State Electronics Concentration

junior year, first semester (18 credit hours)
Phy 212 Electricity and Magnetism I (3)
Phy 260 Laboratory Techniques (2)
ECE 33 Introduction to Computer Engineering (4)
ECE 123 Electronic Circuits (3)
Math 322 Methods of Applied Analysis I (3) AS courses/electives (3)

junior year, second semester (17 credit hours)
Phy 213 Electricity and Magnetism II (3)
Phy 261 Optics, Spectroscopy, and Quantum Physics Laboratory (2)
Phy 362 Atomic and Molecular Structure (3)
**Optical Sciences Concentration**

**junior year, first semester** (16 credit hours)
- Phy 212: Electricity and Magnetism I (3)
- Phy 215: Classical Mechanics (4)
- Math 322: Methods of Applied Analysis I (3)
- OE Elective** (3)
- AS courses/electives (6)

**junior year, second semester** (16 credit hours)
- Phy 213: Electricity and Magnetism II (3)
- Phy 261: Optics, Spectroscopy, and Quantum Physics Laboratory (2)
- Phy 362: Atomic and Molecular Structure (3)
- OE Elective** (3)
- AS courses/electives (6)

**senior year, first semester** (16 credit hours)
- Phy 260: Laboratory Techniques (2)
- Phy 352: Modern Optics (3)
- OE Elective** (6)
- AS courses/electives (6)

**senior year, second semester** (16 credit hours)
- Phy 355: Lasers and Non-linear Optics (3)
- OE Elective** (6)
- AS courses/electives (7)

**fifth year, first semester** (15 credit hours)
- Phy 340: Thermal Physics (3) or ME 104: Thermodynamics I (3)
- AS courses/electives (12)

**fifth year, second semester** (15 credit hours)
- Phy 171: Physics Proseminar (1)
- AS courses/electives (14)

**senior year, second semester** (16 credit hours)
- Phy 175: Classical Mechanics (4)
- Phy 363: Modern Optics (3)
- SSE Elective** (3)
- SSE Elective* or AS courses/electives (3)
- AS courses/electives (3)

**senior year, first semester** (16 credit hours)
- Phy 215: Classical Mechanics (4)
- Phy 363: Physics of Solids (3)
- SSE Elective** (3)
- SSE Elective* or AS courses/electives (3)
- AS courses/electives (3)

**fifth year, first semester** (15 credit hours)
- Phy 340: Thermal Physics (3) or ME 104: Thermodynamics I (3)
- AS courses/electives (12)

**fifth year, second semester** (15 credit hours)
- Phy 171: Physics Proseminar (1)
- AS courses/electives (14)

*The 11 credit hours of SSE electives must include ECE 251 or 252 or Phy 273 (must be a design project with an engineer co-advisor). Advisor has list of approved SSE electives. Must include at least 30 credits taught by engineers and sufficient engineering design and engineering science credits to satisfy ABET guidelines.

The 18 credit hours of Optical Engineering electives must include ECE 251 or 252 or Phy 273 (must be a design project with an engineer co-advisor). Must include at least two of ECE 347, 348, 371, and 372. Advisor has list of approved OE electives. Must include at least 30 credits taught by engineers and sufficient engineering design and engineering science credits to satisfy ABET guidelines.

**Arts-Industrial Engineering**

A total of 162 credit hours is needed for the bachelor of arts and bachelor of science degrees.

**sophomore year, first semester** (17 credit hours)
- Math 23: Calculus III (4)
- Phy 21: Introductory Physics II (4)
- Phy 22: Introductory Physics Lab II (1)
- IE 111: Engineering Probability and Statistics (3)
- IE 112: Computer Graphics (1)
- Eco 1: Principles of Economics (4)

**sophomore year, second semester** (17 credit hours)
- IE 121: Applied Engineering Statistics (3)
- IE 122: Software Tools (1)
- IE 131: Work Systems and Facilities Planning (3)
- IE 132: Work Systems and Facilities Planning Laboratory (1)
- Acct 108: Fundamentals of Accounting (3)
- AS courses/electives (6)

**junior year, first semester** (15 credit hours)
- Math 205: Linear Methods (3)
- IE 221: Operations Research-Probabilistic Models (3)
- Mat 33: Engineering Materials and Processes (3)
- AS courses/electives (6)

**junior year, second semester** (16 credit hours)
- IE 222: Operations Research-Deterministic Models (3)
- ECE 81: Principles of Electrical Engineering (4)
- IE 224: Information Systems Analysis and Design (3)
- AS courses/electives (6)

**senior year, first semester** (14 credit hours)
- IE 115: Fundamentals of Modern Manufacturing (3)
- IE 116: Manufacturing Laboratory (1)
- Mech 2: Elementary Engineering Mechanics (3)
- AS courses/electives (7)

**senior year, second semester** (15 credit hours)
- IE 124: Engineering Economy and Decision Analysis (3)
- ME 104: Thermodynamics I (3)
- IE 305: Simulation (3)
- AS courses/electives (6)

**summer**
- IE 100: Industrial Employment (0)

**fifth year** (36 credit hours)

See program description for senior year of Industrial Engineering.

**Arts-Materials Science and Engineering**

A total of 165 credit hours is needed for the bachelor of arts and bachelor of science degrees, depending on the option selected.

**sophomore year, first semester** (16 credit hours)
- Mat 33: Engineering Materials and Processes (3)
- Math 23: Calculus III (4)
- Phy 21: Introductory Physics II (4)
- Phy 22: Introductory Physics Lab II (1)
- Mat 10: Materials Laboratory (1)
- AS courses/electives (3)
junior year, first semester (16 credit hours)
Chm 209 Chemistry of Organic and Inorganic Materials (3)
Mat 216 Diffusion and Phase Transformations (3)
Mat 218 Mechanical Behavior of Materials (3)
Eco 1 Principles of Economics (4)
AS courses/electives (3)

junior year, second semester (15 credit hours)
Mat 204 Processing and Properties of Polymeric Materials (3)
Mat 206 Processing and Properties of Metals (3)
Mat 214 Processing and Properties of Ceramic Materials (3)
AS courses/electives (6)

senior year, first semester (18 credit hours)
ECE 81 Principles of Electrical Engineering (4)
Mat 101 Professional Development (2)
AS courses/electives (9)

senior year, second semester (15 credit hours)
ECE 81 Principles of Electrical Engineering (4)
Mat 101 Professional Development (2)
AS courses/electives (9)

fifth year (36 credit hours)
See program description for senior year of Materials Science and Engineering.

Note: Students interested in the industrial or research options should consult with the department chairperson prior to their fourth year. Students selecting the research option should elect Mat 240, Research Techniques, in the first semester of the senior year.

Arts-Mechanical Engineering
A total of 161 credit hours is needed for the bachelor of arts and the bachelor of science degrees.

junior year, first semester (16 credit hours)
Phy 21 Introductory Physics II (4)
Phy 22 Introductory Physics Lab II (1)
Math 23 Calculus III (4)
ME 10 Graphics for Engineering Design (3)
ME 111 Professional Development (1)
AS courses/electives (3)

junior year, second semester (18 credit hours)
Mech 2 Elementary Engineering Mechanics (3)
ME 104 Thermodynamics I (3)
Math 205 Linear Methods (3)
AS courses/electives (9)

senior year, first semester (15 credit hours)
Mat 33 Engineering Materials and Processes (3)
Math 208 Complex Variables (3) or Math 230 Numerical Methods (3) or Math 231 Probability and Statistics (3)
ME 252 Mechanical Elements (3)
AS courses/electives (6)

senior year, second semester (16 credit hours)
ME 101 Mechanical Engineering Design I (3)
ME 242 Mechanical Engineering Systems (3)
ME 240 Manufacturing (3)
ME 121 Mechanical Engineering Laboratory II (1)
AS courses/electives (6)

fifth year (33 credit hours)
See program description for senior year of Mechanical Engineering & Mechanics. One of the courses is an AS course/elective (3).

Arts-Master of Business Administration Program

The arts-master of business administration two-degree program is a special opportunity offered by the College of Arts and Sciences. See Section III for a description.

Asian Studies

Professors. John Gatewood, Ph.D. (Illinois), Sociology and Anthropology; Norman Girardot, Ph.D. (Chicago), Religion Studies; Michael Notis, Ph.D. (Lehigh), Materials Science and Engineering; David Pankenier, Ph.D. (Stanford), Modern Languages and Literature; Raymond Wylie, Ph.D. (London, England), International Relations.

Associate professors. Constance Cook, Ph.D. (U.C., Berkeley), Modern Languages and Literature; Kenneth Kraft, Ph.D. (Princeton), Religion Studies; Nicola Tannenbaum, Ph.D. (Iowa), Sociology and Anthropology.

Assistant professors. Gail Cooper, Ph.D. (U.C., Santa Barbara), History; Kiri Lee, Ph.D. (Harvard), Modern Languages and Literature, Michael Mendelson Ph.D. (San Diego), Philosophy.

The Asian Studies program affords undergraduates in any college within Lehigh an opportunity to acquire a systematic knowledge of Asia, specifically East Asia, Southeast Asia and the Pacific. The program focuses on the rich historical and cultural heritage of the countries of Asia, as well as their growing importance in world affairs and their critical relationship to the national interests of the United States.

Additional courses are offered at other LV AIC institutions and may be taken for credit by Lehigh students. In addition, students may avail themselves of a variety of extracurricular activities that are offered in Asian Studies, such as special lectures and seminars, films, performances and exhibits.

The overall program is administered by the Asian Studies Committee, an interdisciplinary body of faculty members with a special interest in the region. This committee oversees both the formal academic work within the program as well as the extracurricular activities sponsored at the university. It also cooperates with the Asian Cultural Society and other campus organizations involved in aspects of Asian Studies.

The courses listed are regularly offered in the program and new ones are currently under development in a number of subject areas. (Consult the Registrar’s Schedule of Classes for specific offerings in any particular semester.)
For further information, interested students should consult Dr. Constance Cook, Director, Asian Studies Program, 519 Maginnis Hall, 758-3091 or any of the Asian Studies faculty listed above.

Major in Asian Studies
The Asian Studies major is designed to accomplish three goals: to ground the student in a regional language and culture (Chinese or Japanese), to survey various disciplines in Asian Studies more broadly, and to provide advanced research opportunities in the upperclass years. The program, when completed successfully, will prepare the student for further graduate work, professional education, or employment in the public or private sector. There is an increasing demand for graduates who combine a major in a disciplinary field (e.g., business, economics, international relations) with a second major (or minor) in Asian Studies, including Chinese or Japanese language competence.

The major in Asian Studies may have a Chinese studies or a Japanese studies concentration, each requiring a minimum of 9 courses (36 credits). The distribution of the credits is as follows, subject to the guidance of the academic advisor, Dr. David Pankenier, Modern Languages and Literature, 515 Maginnis Hall, 758-3090. Full descriptions of all Asian Studies courses are provided in the listings of individual departments.

Minor in Asian Studies
The minor in Asian Studies is intended as a complement to a student's major field of study, and it is flexible according to individual needs. Students are free to survey the field broadly or concentrate in a special area such as Chinese or Japanese studies. The minor is composed of a minimum of 4 courses (16 credits) in Asian studies, chosen from an approved list in consultation with the minor advisor, Dr. David Pankenier, Modern Languages and Literature, 516 Maginnes Hall, 610-758-3090.

Study Abroad Programs
Students are encouraged to spend a summer, semester or year in an approved study program in China, Japan, Korea, Southeast Asia or the Pacific. Students who wish to study abroad, and who wish to have the academic work taken in that program count toward a Lehigh degree, must have a GPA of 2.7 or higher. Any student with a lower GPA may petition the Committee on the Standing of Students for an exception to this rule before applying to an approved study abroad program. These programs are open to all LVAIC students subject to the regulations of their home institutions. For details on all programs, consult Cas Sowa, Lehigh Abroad Program Officer, International Education Office, 343 Whitaker Laboratory, 610-758-3351.

I. Core Requirements
A. Language and Culture: Chinese or Japanese to intermediate level (2 years); 4 courses (16 credits), based on placement, chosen from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chin 1</td>
<td>Elementary Chinese I (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Chin 2</td>
<td>Elementary Chinese II (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Chin 11</td>
<td>Intermediate Chinese I (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Chin 12</td>
<td>Intermediate Chinese II (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Chin 41</td>
<td>Modern Written Chinese I (1-4)</td>
<td>HU</td>
</tr>
<tr>
<td>Chin 42</td>
<td>Modern Written Chinese II (1-4)</td>
<td>HU</td>
</tr>
<tr>
<td>Chin 91</td>
<td>Chinese Language and Culture Abroad (1-8)</td>
<td>HU</td>
</tr>
<tr>
<td>Chin 191</td>
<td>Intermediate Chinese Language and Culture Abroad (1-8)</td>
<td>HU</td>
</tr>
<tr>
<td>Jpns 1</td>
<td>Elementary Japanese I (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Jpns 2</td>
<td>Elementary Japanese II (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Jpns 11</td>
<td>Intermediate Japanese I (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Jpns 12</td>
<td>Intermediate Japanese II (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Jpns 91</td>
<td>Elementary Japanese Language and Culture Abroad (1-8)</td>
<td>HU</td>
</tr>
<tr>
<td>Jpns 191</td>
<td>Intermediate Japanese Language and Culture Abroad (1-8)</td>
<td>HU</td>
</tr>
</tbody>
</table>

*Note 1. Students with prior knowledge of Chinese or Japanese will be placed on the basis of a competence test. Native speakers placing out of the language requirement in part or in whole will be required to take additional Asian studies courses to make up a minimum of 36 credit hours.

B. Humanities and Social Sciences: 3 courses (minimum 10 credits) chosen from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia 31</td>
<td>History of Japanese Industrialization since 1800 (3)</td>
<td>SS</td>
</tr>
<tr>
<td>Asia 61</td>
<td>East Asian International Relations (4)</td>
<td>SS</td>
</tr>
<tr>
<td>Asia 62</td>
<td>Religions of India (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 64</td>
<td>Religions of China (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 65</td>
<td>Religions of Japan (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 67</td>
<td>Japanese Civilization (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 68</td>
<td>Japanese Language Past and Present (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 73</td>
<td>Fiction into Film: Modern Chinese Literature in Translation (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 74</td>
<td>Chinese Cultural Program (1-6)</td>
<td>HU/SS</td>
</tr>
<tr>
<td>Asia 75</td>
<td>Chinese Civilization (4)</td>
<td>HU/SS</td>
</tr>
<tr>
<td>Asia 77</td>
<td>The Islamic Tradition (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 78</td>
<td>Asian-American Studies (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 125</td>
<td>Immortal Images: Traditional Chinese Literature in Translation (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 140</td>
<td>Eastern Philosophy (3)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 141</td>
<td>Science and Technology in East Asia (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 160</td>
<td>The Taoist Tradition (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 161</td>
<td>China in World Affairs (4)</td>
<td>SS</td>
</tr>
<tr>
<td>Asia 162</td>
<td>Zen Buddhism (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 163</td>
<td>Japan in World Affairs (4)</td>
<td>SS</td>
</tr>
<tr>
<td>Asia 164</td>
<td>Japan’s Response to the West (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 168</td>
<td>Buddhism in the Modern World (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 169</td>
<td>Classics of Asian Religions (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 177</td>
<td>China Enters the Modern Age (4)</td>
<td>HU/SS</td>
</tr>
<tr>
<td>Asia 184</td>
<td>Cultures of the Pacific (3)</td>
<td>SS</td>
</tr>
<tr>
<td>Asia 187</td>
<td>Peoples of Southeast Asia (3)</td>
<td>SS</td>
</tr>
</tbody>
</table>

II. Advanced Electives
Two courses (7 or 8 credits) chosen from the following, 1 course (4 credits) of which must be at the 300 level:

A. Language and Culture:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chin 141</td>
<td>Advanced Chinese I (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Chin 142</td>
<td>Advanced Chinese II (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Chin 251</td>
<td>Special Topics (1-4)</td>
<td>HU</td>
</tr>
<tr>
<td>Chin 291</td>
<td>Advanced Chinese Language and Culture Abroad (1-8)</td>
<td>HU</td>
</tr>
<tr>
<td>Chin 371</td>
<td>Special topics (1-4)</td>
<td>HU</td>
</tr>
<tr>
<td>Jpns 141</td>
<td>Advanced Japanese I (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Jpns 142</td>
<td>Advanced Japanese II (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Jpns 290</td>
<td>Special topics (1-4)</td>
<td>HU</td>
</tr>
<tr>
<td>Jpns 291</td>
<td>Advanced Japanese Language and Culture Abroad (1-8)</td>
<td>HU</td>
</tr>
</tbody>
</table>

B. Humanities and Social Sciences:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia 221</td>
<td>Topics in Asian Religions (4)</td>
<td>HU</td>
</tr>
<tr>
<td>Asia 361</td>
<td>Internship in Asian Studies (1-4)</td>
<td>HU/SS</td>
</tr>
<tr>
<td>Asia 364</td>
<td>Seminar in the International Relations of East Asia/Pacific Rim (4)</td>
<td>SS</td>
</tr>
<tr>
<td>Asia 371</td>
<td>Advanced Readings in Asian Studies (4)</td>
<td>HU/SS</td>
</tr>
<tr>
<td>Asia 381</td>
<td>Special Topics in Asian Studies (4)</td>
<td>HU/SS</td>
</tr>
<tr>
<td>Asia 391</td>
<td>Senior Seminar in Asian Studies (4)</td>
<td>HU/SS</td>
</tr>
<tr>
<td>Asia 399</td>
<td>Senior Thesis in Asian Studies (4)</td>
<td>HU/SS</td>
</tr>
</tbody>
</table>
C. Other suitable courses at LVAIC or other approved institutions in the United States.
D. Other suitable courses in approved study abroad programs in East Asia.

ASIAN STUDIES COURSES NOT CROSS LISTED ELSEWHERE IN THE CATALOG

ASIA 361. Internship in Asian Studies (1-4)
Internship in public or private agency involved in some aspect of Asian studies. Individual faculty mentor. Written report required. May be repeated for credit. Program permission required. (HU/SS depending on topic)

ASIA 371. Advanced Readings in Asian Studies (4)
Directed course of reading and writing in advanced topic not covered in regular Asian Studies course offerings. May be repeated for credit. Program permission required. (HU/SS depending on topic)

ASIA 381. Special Topics in Asian Studies (4)
Advanced study of aspects of Asian studies not covered in regular course offerings. Individual faculty supervision. Research paper required. May be repeated for credit. Program permission required. (HU/SS depending on topic)

ASIA 391. Senior Seminar in Asian Studies (4)
Advanced seminar focusing on discussion and research on specialized subjects in Asian studies. Variable matter. Offered by faculty on rotating basis. May be repeated for credit. Program permission required. (HU/SS depending on topic)

ASIA 399. Senior Thesis in Asian Studies (4)
Advanced, individual research project on topic agreed between faculty and student. Research paper and oral defense required. May be repeated for credit. Open to Asian studies majors only. Program permission required. (HU/SS depending on topic)

Astronomy

Professor. George E. McCluskey, Jr., Ph.D. (Pennsylvania), head.

Astronomy is offered in the department of mathematics.

Astr 1. The Solar System (3) fall
Apparent motions of celestial bodies on the celestial sphere; rotation and revolution of planets and satellites; physical properties of the planets, their satellites, asteroids, comets, and meteors; origin of the solar system; the sun. (NS)

Astr 2. Stellar Astronomy (3) spring
Apparent brightnesses, colors, spectra, and absolute properties of stars; the birth, evolution and death of single and binary stars; the interstellar medium; the galaxy; galaxies and clusters of galaxies; the nature of the universe. (NS)

Astr 211. Stellar Structure and Evolution (3) fall, even-numbered years

Astr 221. Stellar Atmospheres (3) fall, odd-numbered years
Observation and theory of stellar spectra. Model atmospheres and chemical abundance. Extended atmospheres, stellar winds and mass loss. Theory of gaseous nebulae. Prerequisites: Math 23 or Math 33, previously or concurrently, and Phys 21. (NS)

Astr 332. (Phy 332) High-Energy Astrophysics (3) spring, odd-numbered years
Observation and theory of X-ray and gamma-ray sources, quasars, pulsars, radio galaxies, neutron stars, black holes. Results from ultraviolet, X-ray and gamma ray satellites. Prerequisites: Math 23 or 33 or 52, previously or concurrently, and Phys 21. (NS)

Astr 342. (Phy 342) Relativity and Cosmology (3) spring, even-numbered years
Special and general relativity. Schwarzschild and Kerr black holes. Supermassive stars. Relativistic theories of the origin and evolution of the universe. Prerequisites: Math 23 or 33 or 52, previously or concurrently, and Phys 21. (NS)

Astr 350. Topics in Astrophysics (3) fall-spring
For science or engineering majors who desire to study an active area of research in astrophysics. Individual supervision. Prerequisites: Astr 2, and Math 23 or Math 33 and Phys 21. May be repeated for credit with the consent of the division head. (NS)

Biochemistry

Interdepartmental B.S. biochemistry majors are offered in both the College of Engineering and Applied Science and the College of Arts and Sciences. The chemistry, biochemistry and collateral science requirements differ somewhat for the two programs. The B.S. in biochemistry degrees in both colleges are managed by an interdepartmental committee composed of biochemists (Alhadef, Behe, Lowe-Krentz, and Schray), bioorganic chemists (Foster, Heindel, and Regen), and molecular/cellular biologists (Cassimeris and Ware). The committee administers the degree, monitors the academic program, provides research possibilities, and advises student majors. The director of the program is currently Linda J. Lowe-Krentz.

Bachelor of Science Degree in Biochemistry, College of Engineering and Applied Science

Freshman year (see Section III) (30 credit hours)
Note: It is recommended that, where possible, students planning to major in chemistry take Chemistry 75 in the fall semester and Chemistry 76 in the spring semester of the freshman year. For such students, the Humanities/Social Science elective in the spring semester is displaced to a subsequent semester. The Chemistry 21/22/31 sequence may be substituted.

Sophomore year, first semester (16 credit hours)

Chm 51 Organic Chemistry I (3)
Chm 53 Organic Chemistry Lab I (1)
Phys 21 Intro. Physics II (4)
Phys 22 Intro. Physics Lab II (1)
Math 23 Analytic Geometry and Calculus III (4)

*Chm 31, Chemical Equilibria, will displace this modern foreign language requirement to a subsequent semester if Chm 31 was not taken in the freshman year. This degree shares the chemistry department's modern foreign language requirement. It can be met by any one of three options: 1) completion of the second semester of a modern foreign language; 2) certification of language equivalent to this level taken in high school; and 3) substitutions of six credits of science electives. If science electives are chosen, non-science distribution requirements must still be met.

Sophomore year, second semester (16 credit hours)

Chm 52 Organic Chemistry II (3)
Chm 58 Organic Chemistry Lab II (1)
Chm 187 Physical Chemistry I (3)
Math 205 Linear Methods (3)
lehigh university course catalog 1999-2000

modern foreign language requirement (3)
biological science elective (3)

junior year, first semester (16 credit hours)
Chm 332 Analytical Chemistry (3)
BioS 371 Elem. of Biochemistry I (3)
BioS 377 Biochem. Lab (3)
Eco 1 Principles of Economics (4)
Humans / Social Science requirement (3)

junior year, second semester (17 credit hours)
BioS 372 Elem. of Biochemistry II (3)
Chm 201 Technical Writing (2)
Humans / Social Science requirement (3)
free electives (6)

senior year, first semester (15 credit hours)
Chm 341 Chemical Physics and Bonding (4)
Chm 192 Physical Chemistry Lab (2)
Advanced laboratory (4)
Biological sciences elective (3)
Humans / Social Science requirement (3)
free elective (3)

senior year, second semester (15 credit hours)
Chm 307 Adv. Inorganic Chemistry (3)
Biological sciences elective (3)
free electives (9)

Summary
Total required chemistry hours 37
Total required biological science hours 18
Total required physics, mathematics, computer hours 28
Total required college distribution hours 24
Unrestricted elective hours 19
Program total hours requirement is 126.

*The nine credit hours of biological sciences electives are chosen with the approval of the adviser.
**The department modern foreign language requirement would normally meet college distribution requirements and be included in the 24 hours. In the event that this is not the case, then unrestricted elective hours will have to be used to meet this modern language requirement.

Bachelor of Science Degree in Biochemistry
College of Arts and Science
I. College and University Requirements (26)
a. English 1,2 (6)
b. Arts and Science 1 (1)
c. First Year Seminar (3)
d. Non-science electives 16 hours to be broadly distributed in fields of thought other than natural science and mathematics, including at least 8 hours each in humanities and social sciences.
II. Collateral Science Requirements at least (24)
a. Physics 11, 12, 13, 14 (or 21, 22) (9 or 10)
b. Mathematics 51,52,43 (or 21, 22, 23) and a statistics course at least (12)
c. Computer Science 11 or Engineering 1 (3)
III. Required Chemistry Courses (25 to 26)
a. Introductory Chemistry Chemistry 75, 76 (8*)
b. Organic Chemistry Chemistry 51, 52, 53 58 (8)
c. Inorganic Chemistry Chemistry 205 or 307 (2 or 3)
d. Physical Chemistry Chemistry 187 or 194 (3)
e. Analytical Chemistry Chemistry 352 (3)
*The Chemistry 21/22/31 sequence may be substituted.
IV. Required Biological Science courses (24)
a. Biochemistry 371, 372, 377 (9)
b. Introduction to Cell and Molecular Biology 31, 32 (4)
c. Advanced Laboratory (4)
d. Electives in Biological Sciences (6 hours minimum*)
e. Technical Writing (2 hours minimum)
*The six credit hours of biological sciences electives are chosen with the approval of the adviser.

Model Pattern Roster
freshman Year
Chm 75, 76 Concepts, Models, and Experiments I and II (8)
BioS 31, 32 Intro. to Cell and Molecular Biology and Laboratory (4)
Math 51, 52 Survey of Calculus I and II (7) or
Math 21, 22 Calculus I and II (8)
Dept 90 College Seminar (3)
Engl 1,2 Composition and Literature (6)
Phy 11,12 Introductory Physics I and Laboratory (5)
sophomore Year
Chm 51,52,53,58 Organic Chemistry and Laboratory (8)
 Phy 13,14 Introductory Physics II-B and Laboratory (4) or
Phy 21,22 Introductory Phys. II and Laboratory
Math 43 Linear Algebra (3) or
Math 23 Calculus III
BioS 110 Experimental Design and Statistical Analysis*
Chm 187 Physical Chemistry I (3)*
BioS elective

*Alternatively, if Chm 194 is elected, it would be taken fall of junior year
**A statistics course from the Math department could also fulfill the statistics requirement.

junior year
Chm 332 Analytical Chemistry (3)
BioS 371,372 Elem. of Biochemistry I and II (6)
BioS 377 Biochem. Lab (3)
Chm 205 Main Group Elements (2)*
CSc 11 Introduction to Computing (3)
Technical Writing (2)

*If Chm 194 is taken in the junior year, Chm 205 would be displaced to senior year. If Chm 307 is elected in place of Chm 205, it would be taken in the senior year.

senior year
BioS Advanced laboratory course(s)
BioS elective

Biological Sciences

Professors. Neal Simon, Ph.D. (Rutgers), chair; John H. Abel, Ph.D. (Brown); Barry Bean, Ph.D. (Rockefeller); Michael J. Behe, Ph.D. (Pennsylvania); David Cundall, Ph.D. (Arkansas); Murray Itzkowitz, Ph.D. (Maryland); Steven Krawiec, Ph.D. (Yale); John Nyby, Ph.D. (Texas); Jeffrey A. Sands, Ph.D. (Penn State).

Associate professors. Lynne Cassimeris, Ph.D. (North Carolina); Michael R. Kuchka, Ph.D. (Carnegie Mellon); Linda J. Lowe-Krentz, Ph.D. (Northwestern); Jill Schneider, Ph.D. (Wesleyan), Class of 1961 Professor; Jennifer Swann, Ph.D. (Northwestern); Vassie C. Ware, Ph.D. (Yale).

Adjunct professors. Janice A. Phillips, Ph.D. (Pennsylvania); Martin L. Richter, Ph.D. (Indiana).

The biological sciences include the study of living systems at levels ranging from the structure and function of molecules to the behavior and evolution of communities of organisms. The department offers four different routes to mastering skills and knowledge in this broad area. The B.A. and B.S. programs in biology provide a broad introduction to biology with opportunities for students to create a program of study suited to
their specific interests. Programs of study focused on particular aspects of biology are the B.A. and B.S. degrees in the areas of behavioral neuroscience and molecular biology and the two interdepartmental B.S. degrees in biochemistry managed in conjunction with the chemistry department (one of the biochemistry degrees is in the engineering college). For programs in ecology and environmental biology, see the Department of Earth and Environmental Sciences listing. The requirements for the B.A. and B.S. in biology, behavioral neuroscience, and molecular biology are listed below. Research interests of the faculty and instrumentation are described in the section on graduate education.

**B.A. with Major in Biology**

College and university requirements (26 credit hours)
- Eng I  Composition and Literature (6)
- Arts I  Choices and Decisions (1)
- First Year Seminar (3)
- Social Sciences (8)
- Humanities (8)

**Major Program (48-49 credit hours)**

**Biology (30 credit hours)**
- EES 31  Intro. to Environmental and Organismal Biology (4)
- BioS 31  Intro. to Cell and Molecular Biology (3)
- BioS 32  Intro. Cell/Molecular Laboratory (1)
- BioS 101  Genetics (3)
- BioS 102  Genetics Laboratory (1)
- Electives  Biology approved electives (18 credit hours)

**Mathematics (7 credit hours)**
- Math 51  Survey of Calculus I (4)*
- Math 52  Survey of Calculus II (3)*

**Chemistry/Physics (11 credit hours)**
- Chm 21  Introductory Chemical Principles (4)*
- Chm 22  Chemical Principles Laboratory (1)*
- Chm 51  Organic Chemistry (3)

and one of the following:
- Chm 31  Chemical Equilibria in Aqueous Systems (3)
- Chm 194  Physical Chemistry for Biological Sciences (3)
- Phy 11  Introductory Physics I (4)

*Although no specific sequence is required, it is recommended that courses marked with an asterisk be completed during the freshman year.

**The B.S. in Biology**

The bachelor of science in biology offers broad scientific preparation in biology to facilitate advanced work in the life sciences. Progression through the program is best served through early commitment.

**Requirements for the B.S. in Biology**

**College and university requirements (26 credit hours)**
- Eng I  Composition and Literature (6)
- Arts I  Choices and Decisions (1)
- First Year Seminar (3)
- Social Sciences (8)
- Humanities (8)

**Major Program (74 credit hours)**

**Biology (37 credit hours)**
- BioS 31  Intro. to Cell and Molecular Biology (3)
- BioS 32  Intro. Cell and Molecular Biology Lab (1)
- BioS 101  Genetics (3)

- BioS 102  Genetics Laboratory (1)
- BioS 317  Evolution (3)
- Electives  Biology electives (26)

*Biology electives must include one course from list A, one course from list B and at least four credits of laboratory experience (e.g. two 2 credit laboratory courses). These will be chosen in consultation with the major advisor.

List A
- BioS 313  Vertebrate Histology (4)
- BioS 314  Vertebrate Development (3)
- BioS 335  Animal Behavior (3)
- BioS 337  Behavioral Ecology (3)
- BioS 375  Neuroanatomy of Behavior (3)
- BioS 382  Endocrinology of Behavior (3)

List B
- BioS 324  Bacteriology (3)
- BioS 345  Molecular Genetics (3)
- BioS 353  Virology (3)
- BioS 356  Human Genetics and Reproduction (3)
- BioS 367  Cell Biology (3)
- BioS 371  Elements of Biochemistry I (3)

**Mathematics (12 credit hours minimum)**
either
- Math 51, 52, 43  Survey of Calculus I, II and Linear Algebra (10)

**Collateral Sciences (25 credit hours)**
- Chm 75, 76  Concepts, Models and Experiments I and II (8)
- Chm 51, 52  Organic Chemistry I and II (6)
- Chm 53, 58  Organic Chemistry Laboratory I and II (2)
- Phy 11  Introductory Physics I (4)
- Phy 12  Introductory Physics Laboratory I (1)
- Phy 13  General Physics (3)
- Phy 14  General Physics Lab (1)

**Recommended B.S. Biology Sequence**

**Freshman Year**
- BioS 31  Intro. to Cell and Molecular Biology (3)
- BioS 32  Intro. Cell/Molecular Laboratory (1)
- Math 51, 52  Survey of Calculus I and II (7)
- Chm 75, 76  Concepts, Models and Experiments I and II (8)
- Arts 1  Choices & Decisions (1)

**Sophomore Year**
- BioS 101  Genetics (3)
- BioS 102  Genetics Laboratory (1)
- Chm 51, 52, 53, 58  Organic Chemistry and Laboratory (8)
- Math 43  Survey of Linear Algebra
- BioS/Psyc 110  Experimental Design and Statistical Analysis (4)

**Junior Year**
- Phy 11, 12  Introductory Physics I and Laboratory (5)
- Phy 13, 14  General Physics and Laboratory (4)

**Senior Year**
- BioS 317  Evolution (3)
- Elective  Biology electives including at least 4 credits of laboratory (10-14)
Minor in Biology
A minor in biology may be achieved by completing the following requirements (27 credits):
- EES 31 Intro. to Environmental/Organismal Biology (4)
- BioS 31, 32 Intro. to Cell and Molecular Biology and Laboratory (4)
- BioS 101, 102 Genetics and Genetics Laboratory (4)
- Chm 21, 22 Introductory Chemical Principles and Laboratory (5)
- Chm 51 Organic Chemistry (3)
- Math 51 Survey of Calculus I (4)
- Elective Biology electives (3)

B.A. in Behavioral Neuroscience
The B.A. in Behavioral Neuroscience is a traditional liberal arts degree which can be structured for a wide variety of possibilities for B.A. distribution purposes.

Required Major Courses
Core Courses
- Psyc 1 Introduction to Psychology (4)
- EES 31 Intro. to Environmental and Organismal Biology (4)
- BioS 31 Introduction to Cell and Molecular Biology (3)
- BioS 32 Introduction to Cell and Molecular Biology Laboratory (1)
- BioS 101 Genetics (3)
- BioS/Psyc 110 Design and Analysis of Experiments (3)
- BioS 277 Experimental Neuroscience Laboratory (4) or Psych 210 Experimental Psychology (4)
- BioS 177 Introduction to Behavioral Neuroscience (3)
- BioS 375 Neuroanatomy of Behavior (3)
- BioS 382 Endocrinology of Behavior (3)

Major electives (6 credits)
- BioS 134 Comparative Vertebrate Anatomy (4)
- BioS 221 Human Histology (4)
- BioS 229 Immunology (3)
- BioS 313 Vertebrate Histology (4)
- BioS 314 Vertebrate Development (3)
- BioS 317 Evolution (3)
- BioS 324 Bacteriology (3)
- BioS 335 Animal Behavior (3)
- BioS 337 Behavioral Ecology (3)
- BioS 345 Molecular Genetics (3)
- BioS 353 Virology (3)
- BioS 356 Human Genetics and Reproduction (3)
- BioS 367 Cell Biology (3)
- BioS 371, 372 Elements of Biochemistry I & IT (6)
- BioS 377 Biochemistry Laboratory (3)
- Phy 11, 12 Introductory Physics and Laboratory (5)
- Phy 13, 14 General Physics I and Laboratory (4)
- Phy 21, 22 Introductory Physics II and Laboratory (5)

University and college requirements for the B.S.
Engl 1 Composition and Literature (3)
Engl 2, 4, 6, 8, 10 Composition and Literature (3)
Arts I Choices and Decisions (1) or First Year Seminar (3)

Non-science electives (16) to be broadly distributed in fields of thought other than the natural sciences and mathematics, including at least 8 credit hours each in the humanities and social sciences.

Requirements for the B.A. in Molecular Biology
College and university requirements (see Section III).
A. Arts I, Choices and Decisions 1 credit
B. College Seminar 3 credits
C. English composition 6 credits
D. Mathematical sciences 3-4 credits*
E. Sciences 8 credits
F. Social sciences 8 credits
G. Humanities 8 credits+

The B.A. in Molecular Biology (30 credit hours)
- BioS 31, 32 Introduction to Cell & Molecular Biology (3) and Lab (1)
- BioS 101, 102 Genetics (3) and Lab (1)
- BioS 324, 325 Bacteriology (3) and Lab (2)
- BioS (Chm) 371 Elements of Biochemistry I (3)
- BioS 345, 346 Molecular Genetics (3) and Lab (2)
- BioS 367 Cell Biology (3)
- BioS electives (6 credit hours)

Mathematics (8-10 credit hours)
- Math 21 and 22 Calculus I & II (8) or Math 51, 52, 43 Survey of Calculus I & II and Linear Algebra (10)

Chemistry (13 credit hours)
- Chm 21, 22 Introductory Chemical Principles (3) and Lab (1)
- Chm 51, 52, 53, 58 Organic Chemistry I, II and Lab I & II (8)

Physics (5 credit hours)
- Phy 11, 12 Introductory Physics I and Lab I (5)
Chemistry

- The mathematics distribution requirement is satisfied by courses required in the major.

- Three credit hours of the humanities distribution requirement are satisfied by the philosophy requirement in the major.

Requirements for the B.S. in Molecular Biology

College and university requirements (26 credit hours)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>Engl 1</td>
<td>Composition and Literature (3)</td>
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<tr>
<td>Engl 2, 4, 6, 8, 10</td>
<td>Composition and Literature (3)</td>
</tr>
<tr>
<td>Arts 1</td>
<td>Choices and Decisions (1)</td>
</tr>
<tr>
<td>First Year Seminar (3)</td>
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</tbody>
</table>

Non-science electives (16), to be broadly distributed in fields of thought other than natural sciences and mathematics, including 8 credit hours each in the humanities and social sciences.

Major Program (93 credit hours)

Mathematics (12 credit hours)

- Math 21, 22, 23 Calculus I, II and III (12 credit total)
- Math 51, 52, 43 and one of Math 12, or 231 or BioS/Psy 110 (13-14, credit total)

Chemistry (19 credit hours)

- Chm 21 Introductory Chemical Principles (4)
- Chm 22 Chemical Principles Laboratory (1)
- Chm 51, 52 Organic Chemistry I and II (6)
- Chm 53, 58 Organic Chemistry Laboratory (2)
- Chm 31, 194 Chemical Equilibria in Aqueous Systems and Physical Chemistry for Biological Sciences (6)

Physics (9-10 credit hours)

- Phy 11 Introductory Physics I (4)
- Phy 12 Introductory Physics Laboratory I (1)
- Phy 13 (or 21) General Physics (3 or 4)
- Phy 14 (or 22) General Physics Lab (1)

Natural sciences, mathematics or computing science (6 credit hours) electives (6)

Free electives (12 credit hours)

Molecular Biology (37-39 credit hours)

- BioS 31 Intro. to Cell and Molecular Biology (3)
- BioS 32 Intro. to Cell and Molecular Biology Lab (1)
- BioS 101 Genetics (3)
- BioS 102 Genetics Laboratory (1)
- BioS 324 Bacteriology (3)
- BioS 325 Bacteriology Laboratory (2)
- BioS 345 Molecular Genetics (3)
- BioS 346 Molecular Genetics Laboratory (2)
- BioS 367 Cell Biology (3)
- BioS (Chm) 371 Elements of Biochemistry I (3)
- BioS (Chm) 372 Elements of Biochemistry II (3)
- Approved Molecular Biology Electives (12-10)

Recommended sequence for the B.S. in Molecular Biology

Freshman Year

- BioS 31 Intro. to Cell and Molecular Biology (3)
- BioS 32 Intro. Cell/Molecular Laboratory (1)

Sophomore Year

- BioS 211, 221 Genetics (3)
- BioS 102 Genetics Laboratory (1)
- Math 23 Calculus III (4)
- Chm 51, 52 Organic Chemistry (6)
- Chm 53, 58 Organic Chemistry Laboratory (2)
- Phy 11, 12 Introductory Physics I and Lab (5)
- Chm 14, 13 General Physics and Laboratory (or 21, 22) (4 or 5)

Junior Year

- BioS 324 Bacteriology (3)
- BioS 325 Bacteriology Laboratory (2)
- BioS 345 Molecular Genetics (3)
- BioS 346 Molecular Genetics Laboratory (2)
- Chm 31 Chemical Equilibria in Aqueous Systems (3)
- BioS 371, 372 Elements of Biochemistry I and II (6)
- Approved Molecular Biology Electives (3-4)

Senior Year

- Approved Molecular Biology electives (7-8)
- BioS 367 Cell Biology (3)
- Chm 194 Physical Chemistry for Biological Sciences (3)
- Natural science electives (6)

Molecular Biology Minor

The molecular biology minor program consists of BioS 31 (3), 32 (1, 101 (3), 102 (1), 345 (3), 346 (2), and a minimum of 4 additional credits of BioS coursework above the 100 level. Collateral coursework must include: Math 51 or 21 (4 credit hours), Chm 21 (4), Chm 22 (1), and Chm 51 (3).

Departmental Honors

A student may apply for admission to the departmental honors program through a potential thesis advisor. Requirements for Departmental Honors include a major GPA of 3.25 and at least 2 semesters of research for a minimum of 6 cr. The student must write a research proposal for their project and a thesis at the conclusion of their research. This work must be presented in a symposium at the end of the project. Students must meet regularly to discuss their research progress either in BioS 387 and BioS 388 or with their advisor and research group to facilitate progress in the research project.

Undergraduate Courses in Biological Sciences

BioS 1. Molecular Biology and Society (3)
Basic and applied molecular biology for non-science majors. Gene cloning; human gene therapy; cancer; reproduction; contraception; viral infections including AIDS. Ethical considerations. May not be used in satisfaction of life science major or minor programs. (NS)

BioS 2. Animal Survival and Adaptation (3) Summer
Introductory course in evolutionary biology for nonscience majors. Why species appear, change, become successful, divide into several species, and eventually become extinct. Lecture and laboratory experience. (NS)

BioS 7. Human Reproduction (3)
Basic and applied human reproductive biology for non-science majors. May not be used in life science major or minor programs. (NS)

BioS 31. Introduction to Cell and Molecular Biology (3)
Introduction to the structure, function, and evolution of cells at the level of molecules, organelles, and differentiated cell types. Includes basic structure and expression of genes, cell physiology, and the molecular/ cellular basis of disease and immunity. Prerequisite: Chm 21 previously or concurrently. (NS)
BioS 32. Introduction to Cell and Molecular Biology Lab (1)  

BioS 77. Drugs and Behavior (3)  
Basic principles of drug action in the central nervous system. Effects of stimulants, depressants, intoxicants and drug abuse on behavioral function. Clinical use of drugs in the treatment of various psychological and psychiatric disorders. (NS)

BioS 101. Genetics (3)  

BioS 102. Genetics Laboratory (1)  
Laboratory work that demonstrates major principles of genetics: included are experiments on microorganisms and the common fruit fly, Drosophila melanogaster. Prerequisite: BioS 101, preferably concurrently.

BioS 110. (Psyc 110) Design and Analysis of Experiments (4)  
Principles of experimental design and statistical analysis; characteristics of data and data collection; descriptive statistics; hypothesis testing theory and practice; correlation, chi-square test, t-test, analysis of variance. (ND)

BioS 133. Invertebrate Zoology (4)  
Survey of representative invertebrates. Structure and behavior of selected types and concepts of evolutionary relationships among the major groups. Two lectures and two laboratory periods. Prerequisite: EES 31 or BioS 31/32. (NS)

BioS 134. Comparative Vertebrate Anatomy (4)  
A course in vertebrate zoology with emphasis on the study of homologous body structures in the various vertebrate classes and their relationship to the functional demands of habitat and environment in each class. Detailed dissections of representative vertebrates are made in the laboratory. Two lectures and two laboratory periods. Prerequisite: Consent of department. (NS)

BioS 151. (EES 151) Plants and Plant Communities (4)  
Structure and function of plants and plant communities. Discussion of plant physiology and environmental factors controlling plant distribution; structural and physiological adaptations of plants to their environment; the role of the physical environment, competition, herbivory, and disturbance in structuring plant communities; the evolution of plants and communities. Prerequisite: EES 31. (NS)

BioS 161. Supervised Research (1-3) fall-spring  
Apprenticeship in ongoing faculty research program. Literature review, experimental design, data collection and analysis, and professional writing under faculty sponsor supervision. May be repeated once for credit. Prerequisite: Consent of department. (ND)

BioS 177. (Psyc 177) Introduction to Behavioral Neuroscience (3)  
Nervous system functioning with varying emphasis on neurophysiology, neuroanatomy, behavior genetics, information transmission, research techniques, sensory and motor functions. Prerequisite: EES 31 or BioS 31. (NS)

BioS 181. Introduction to Anatomy, Physiology, and Behavior (4)  
Together anatomy and physiology encompass structure and function of the various body systems. Coverage includes: skeletal, muscle, nervous, special senses, endocrine, blood, circulatory, immune, respiratory, digestive, urinary, and reproductive systems. This course uses a variety of laboratory experiences as the foci for learning basic information about how animals function. The introduction to anatomy in each system provides the background for the physiological and behavioral studies. The laboratory exercises include the use of computer linked equipment to measure physiological parameters as well as more traditional physiological experiments. The course will emphasize critical thinking skills in laboratory and discussion. Prerequisite BioS 31/32 and Chem 21/22 or 76. (NS)

BioS 202. Biomedical Externship (1 or 2)  
Analysis of individualized experiences at external biomedical clinical or research sites. Limited enrollment. May not be taken for pass-fail grading. Prerequisite: Consent of department chair required. (NS)

BioS 221. Human Histology (4)  
Human tissues and organs. Emphasis on structural and functional interrelationships of cells. Disease states and pathologies. Two lectures and one laboratory. Prerequisite: BioS 101. (NS)

BioS 225. Introduction to Biological Research (3)  
Literature and methods of research in area of department faculty expertise. Requires development of detailed proposal for research to be performed in senior year. Prerequisites: Major in any biological sciences degree program; junior standing; GPA of 3.0 in major; and consent of the department chair. (ND)

BioS 229. Immunology (3)  
Distinction of “self” and “non-self” through humoral and cellular mechanisms. Antigens; biochemical structures, cellular mechanisms, genetic control and processing, phylogenetic distribution, diseased states. Prerequisite: BioS 101. (NS)

BioS 241. Vertebrate Natural History (4)  
An introduction to the ecology, behavior, distribution and evolution of vertebrates, with emphasis on the North American fauna. Two lectures, one tutorial and one laboratory and field trip. This course may be used to fulfill junior writing requirements with the permission of the instructor. Prerequisite: BioS 134. (NS)

BioS 251. Writing and Biological Sciences (3)  
A course designed to acquaint students with some of the intellectual foundations of science, with attention to the distinctiveness of molecular biology. Format includes readings, intensive writing, extemporaneous speaking, and discussion. Prerequisite: Consent of department. (NS)

BioS 252. (EES 251) General Ecology (4)  
Basic principles and applications of ecological interrelationships. Examination of ecological phenomena at the individual, population, community, and ecosystem levels. Impact of human activities on global ecosystems. Prerequisite: EES 31. (NS)

BioS 261. Special Topics in Biological Sciences (1-3)  
Research, conferences and reports on selected topics not covered in the general undergraduate offerings. May be taken more than once for credit. Prerequisite: Consent of the department chair. (NS)

BioS 277. Experimental Neuroscience Laboratory (4)  
Nervous system structure, preparation of nervous tissues for microscopic examination, experiments on behavioral assays of nervous system function. Report writing and an independent research project. Fulfills junior level writing requirement. Prerequisites: BioS 177 and consent of department chair. (NS)

For Advanced Undergraduates and Graduate Students  
BioS 313. Vertebrate Histology (4)  
Microstructural and ultrastructural properties of vertebrate cells and tissues. Techniques of tissue preparation. Two lectures and two labs. Prerequisite: BioS 134. (ND)
BioS 314. Vertebrate Development (3)
Germ cell formation, fertilization, early development, and the origin of the principal organ systems. Location, structure, and regulation of information from molecular to organismal levels of organization. Prerequisite: BioS 101 and BioS 134. (NS)

BioS 317. Evolution (3)
Mechanisms of evolution, emphasizing genetic structure and variation of populations, and isolation. Origin of species and higher taxa. Rates of evolution, extinction. Prerequisite: BioS 101. (NS)

BioS 324. Bacteriology (3)
The structure, physiology, growth, genetics and taxonomy of prokaryotes. Prerequisites: Chm 51 and BioS 101. Corequisite: BioS 325. (NS)

BioS 325. Bacteriology Laboratory (2)
Standard procedures and metabolic tests used in determinative bacteriology; aseptic technique, sterilization, enumeration, and control of bacterial growth; other selected topics. Prerequisites: BioS 101 and BioS 134.

BioS 329. Herpetology (3)
Biology of amphibians and reptiles. Two lectures, one laboratory or field trip per week. Prerequisite: Consent of department. (ND)

BioS 335. (Psych 335) Animal Behavior (3)
Discussion of the behavior of invertebrates and vertebrates and analysis of the physiological mechanisms responsible for behavioral stimuli, and adaptive value of specific behavior patterns. Prerequisite: EES 31 or BioS 101. (NS)

BioS 336. Animal Behavior Laboratory (2)
Experiments and field observations illustrating principles discussed in BioS 335. Emphasis on observing animals, performing experiments, collecting and analyzing data, and individual research. Six hours of laboratory per week. Corequisites: BioS 335 or 337.

BioS 337. Behavioral Ecology (3)
Social systems of vertebrate and invertebrate groups. Emphasis on ecological and evolutionary factors that influence social behavior. Prerequisites: EES 31 or BioS 101. (NS)

BioS 345. Molecular Genetics (3)
The organization and replication of genetic material; mutagenesis; mechanisms of regulation; mechanisms of gene transmission involving prokaryotes and eukaryotes and their viruses; techniques for intervention into genetic organization and expression. Prerequisite: BioS 101. (NS)

BioS 346. Molecular Genetics Laboratory (2)
Laboratory experiments related to the topics covered in BioS 345. Emphasis is on molecular characterization of DNA and the principles of gene isolation and transfer. Corequisite: BioS 345.

BioS 347. Advanced Topics in Genetics (3)
Lectures and student projects on selected aspects of genetics such as the genetics and evolution of particular organisms, regulation of gene expression and transmission, human genetics, gene therapy, etc. Prerequisites: BioS 345 or consent of department chair. (NS)

BioS 351 (EES 351) Limnology (4)
Physical, chemical, and biological aspects of freshwater environments, including cyclic and seasonal changes. Major groups of organisms and their interactions. Prerequisite: EES 31. (NS)

BioS 353. Virology (3)
Structure and replication of viruses. Emphasis on the organization, replication, and regulation of expression of viral genomes; the mechanisms of virus assembly and release; and on virus-host interactions. Special attention given to human pathogenic viruses. Prerequisite: BioS 101. (NS)

BioS 354. (EES 353) Environmental Microbiology (4)
The role of microorganisms in the environment. Topics include: Survey of microbial classification, structure, and metabolism; study of microbes at population, community, and ecosystem levels of organization; the role of microbes in biogeochemical cycles; application of microbes to bioremediation and resource recovery problems. Fall (alternate even) years. Prerequisite: EES 31 and EES 251, or consent of instructor. (NS)

BioS 355. (EES 355) Ecological Field Methods (4)
An intensive field course designed to familiarize students with field sampling techniques, data analysis, and report writing related to field-based ecological research. Includes description and mapping of plant and animal communities, population dynamics, and plant-animal interactions in terrestrial and aquatic habitats. Weekend field trip to Lacawac Sanctuary. Pre-or corequisite: EES 251. (NS)

BioS 356. Human Genetics and Reproduction (3)
Processes and mechanisms of human heredity. Emphasis at the cellular and molecular levels. Analysis, organization, expression, and evolution of human genome. Genetic aspects of reproduction and development, mapping human chromosomes, cell hybridization, molecular analysis of gene structure and function, behavior and intelligence, primate origins and evolution, immunogenetics, cancer and oncogenes, genetic technologies. Prerequisite: BioS 101. (NS)

BioS 361. Special Topics (3)
Readings, conferences, and reports on a selected topic not covered in other course offerings. May be taken only once for credit. Prerequisites: Consent of instructor. (NS)

BioS 362. (EES 361) Environmental Animal Physiology (4)
Response of animals to their environment, including adaptations for stressful habitats and homeostatic mechanisms. Levels of response and adaptation range from cells and tissues to organ systems and whole organisms. Lecture and recitation. Prerequisites EES 31 and BioS 31. (NS)

BioS 367. Cell Biology (3)
Molecular aspects of cell biology. Emphasis on membrane structure and function, organelle biogenesis, cell motility, the cytoskeleton, and extracellular matrix. Prerequisite: BioS 101. (NS)

BioS 370. Plant Molecular Biology (3)
Molecular aspects of photosynthesis; chloroplast biogenesis; plant gene expression; plant development; plant-microbe interactions; genetic engineering in plant systems. Prerequisite: BioS 345. (NS)

BioS 371. (Chm 371) Elements of Biochemistry I (3) fall
A general study of carbohydrates, proteins, lipids, and nucleic acids and other biological substances and their importance in life processes. Protein and enzyme chemistry are emphasized. Prerequisite: one year of organic chemistry. (NS)

BioS 372. (Chm 372) Elements of Biochemistry II (3) spring
Dynamic aspects of biochemistry; enzyme reactions including energetics, kinetics and mechanisms; metabolism of carbohydrates, lipids, proteins and nucleic acids; photosynthesis, electron transport mechanisms, coupled reactions, phosphorylations, and the synthesis of biological macromolecules. Prerequisite: Chm 371. (NS)

BioS 373. (Psych 373) Sensation and Perception (3) spring
Receptor processes of vision, audition, touch, taste, and smell. Psychological dimensions of such processes leading to consideration of perception as characteristic of organisms. Prerequisite: Psych 117 or 176 or 177. (NS)
BioS 375. (Psych 375) Neuronanatomy of Behavior (3)
Neuronanatomy and neurophysiology of animal and human behavior. Feeding, thirst, sleep, emotions, learning, and psychopathology. Prerequisite: BioS/Psyc 177. (ND)

BioS 376. Classical & Molecular Embryology (3)
Differentiation of multicellular organisms from a single cell. Axis determination, gradients; induction and pattern formation viewed through modern analysis of regulated gene expression. Prerequisite: BioS 345 (previously or concurrently). (NS)

BioS 377 (Chm 377). Biochemistry Laboratory (3) Fall
Laboratory studies of the properties of chemicals of biological origin and the influence of chemical and physical factors on these properties. Laboratory techniques used for the isolation and identification of biochemicals. Prerequisite: BioS/Chm 371 previously or concurrently. (ND)

BioS 378 (Chm 378). Biochemical Preparations (1-3) Spring
A laboratory course involving the preparation or isolation, purification and identification of chemicals of biological origin. Prerequisites: BioS/Chm 377 and 372, previously or concurrently. (ND)

BioS 382. (Psych 382) Endocrinology of Behavior (3)
Hormonal effects upon animal and human behavior. Emphasis on neuroendocrinology of steroid hormone involvement in reproductive behaviors. Prerequisite: BioS/Psyc 177. (NS)

BioS 383. Biological Sciences Colloquia (1)
Analysis of weekly colloquia in molecular biology. For senior biology and molecular biology majors. May be taken twice for credit. (ND)

BioS 387. Biological Sciences Honors Seminar (1)
Development, presentation and implementation of research proposals, and discussions of research. Required for senior biology and molecular biology majors pursuing departmental honors. Departmental permission required. (ND)

BioS 388. Biological Sciences Honors Seminar (1)
Continuation and extension of BioS 387. Departmental permission required. (ND)

BioS 391. Undergraduate Research (1-3)
Laboratory research under tutorial with a faculty member. May be taken more than once for credit. Prerequisites: junior standing, and consent of instructor. (ND)

BioS 393. Thesis (3) Fall
Literature review and design of project in selected area. Intended for senior majors in BioS only. Prerequisite: Consent of faculty sponsor. (ND)

BioS 394. Thesis (3) Spring
Execution of project designed in BioS 393. Final report and oral presentation. Prerequisite: BioS 393 and consent of faculty sponsor. (ND)

Special Health Professions Programs
Students may apply for admission to an accelerated B.A.-Doctor of Medicine program and a B.A.-Doctor of Medical Dentistry program. A six-year B.A.-M.D. program is offered in conjunction with the Medical College of Pennsylvania, and a seven-year B.A.-D.M.D. program is offered in conjunction with the University of Pennsylvania School of Dental Medicine. Students in these programs receive a B.A. from Lehigh and a graduate degree from the designated professional school within a six- or seven-year period. For details concerning admission to these programs, see Health Professions, Section III. Undergraduate courses, please see listings for BioS and EES.

Graduate Study in the Biological Sciences
Rigorous, research-oriented graduate programs leading to a Doctor of Philosophy are offered in three divisions of the Department of Biological Sciences: biochemistry, integrative biology, and molecular biology. To complete the program, students must successfully complete core courses, pass a qualifying exam, prepare, submit, and successfully defend a written research proposal, complete the research described in the proposal, and submit a written dissertation and defend the completed research to the department.

Once students enter the department, their progress is monitored by the graduate committee until they are admitted to candidacy. Members of the committee meet with the student each semester to assess the student's progress towards the degree and to assist students in choosing the appropriate courses to provide a solid scientific foundation and an up-to-date understanding of the discipline. This will be assessed by the qualifying exam.

The qualifying exam generally should be taken after the third semester and no later than the fourth semester of course work. It will be prepared, administered and graded by the faculty associated with the specific graduate program in which the student is enrolled. It consists of a two-day written exam and an oral examination. The exam can be repeated once. Admission to candidacy is granted after successful completion of the qualifying exam and the thesis proposal. The proposal is a written description of an original research project developed under the guidance of a faculty member chosen by the student to be his/her advisor. The proposal will be presented orally to the thesis committee, typically after the fifth semester. Following the presentation of the proposal, an oral examination will take place in which the thesis committee will question the student about general science related to the project. This will constitute the general examination.

Core requirements for each division are listed below. The graduate school requires students to register for at least 72-post baccalaureate credits to earn the Ph.D. In addition, all students must take BioS 406 (6 credits) Responsible Conduct of Science within their first year of graduate study. All students must also attend departmental seminars and enroll in BioS 406 (1 credit) Biological Sciences Seminar at least twice in the first four semesters. A minimum of 24 course credits may be chosen from upper level courses in biochemistry, molecular biology, cell biology, behavioral biology and evolutionary biology, and neuroscience. At least 12 of these credits must be at the 400 level.

In the biochemistry program, research areas include DNA structure and function, regulation of protein synthesis, and signal transduction. Students admitted to graduate study in biochemistry will typically have an undergraduate degree in chemistry or biochemistry. Students with an undergraduate degree in a related discipline will be expected to have the following undergraduate preparation for graduate study beyond introductory chemistry and a year of organic chemistry: at least one semester of analytical chemistry and one semester of physical chemistry - thermodynamics and kinetics, with appropriate math. Students without that background will be expected to take courses to fulfill those requirements as part of their graduate study. Required courses: BioS 371, 372 Elements of Biochemistry I and II, BioS 469, 470 Biochemical Problem Solving I and II, Chm 423 Bio-Orgnic Chemistry, BioS 345 Molecular Genetics, and a seminar course. BioS 408 or Chm 400 must also be completed before beginning research.

The graduate program in integrative biology is designed to train students in advanced organismal biology with the emphasis on behavioral ecology, evolution, functional morphology, endocrinology, and neurobiology of animals. The mission of the program is to create students who are broadly trained and uniquely capable of asking questions and solving problems at the interface of these traditionally defined fields. Students admitted to the program should have a basic knowledge of evolution, anatomy, physiology, behavioral
neuroscience, and/or behavioral ecology. Students will begin by taking core courses providing a broad foundation in integrative biology at the graduate level and work toward a Ph.D. with a concentration in either behavioral neuroscience or behavioral and evolutionary biology. Regardless of concentration, all students in the program develop an appreciation for the fact that all aspects of biology, whether cellular, physiological, anatomical, behavioral, environmental, or social, are inextricably linked and cannot be fully understood as separate, parallel systems of knowledge. Core courses: BioS 439 Advanced Behavioral Ecology, BioS 409 Evolutionary and Functional Morphology, BioS 457 Advanced Behavioral Neuroendocrinology, BioS 453 General Neuroanatomy, one year of a graduate level statistics sequence – either Psy 421 and 422 Analysis and Design of Experiments or Edu 410 and 411 Univariate and Multivariate Statistics, BioS 406 Biological Sciences Seminar, and BioS 408 Responsible Conduct of Science. Additional requirements include 2 electives from the concentration in behavioral and evolutionary biology: BioS 429 Advanced Herpetology, BioS 409 Advanced Morphology, and BioS 445 Systematics and Evolution or 2 electives from the concentration in neuroscience: BioS 411 Advanced Cell Biology, BioS 421 Molecular Cell Biology I (prerequisite is BioS 411), BioS 422 Molecular Cell Biology II (prerequisite is BioS 421), BioS 371 Elements of Biochemistry, BioS 372 Elements of Biochemistry II (prerequisite is BioS 371), or BioS 471 Eukaryotic Biochemistry (prerequisite is BioS 372 or permission of instructor).

In the molecular biology program, research areas include microbial evolution and genetics, plant and animal molecular genetics, eukaryotic cell biology, and regulation of gene expression. Required core courses include BioS 345 Molecular Genetics, BioS 372 Elements of Biochemistry, BioS 411 Advanced Cell Biology, BioS 421 Molecular Cell Biology I, and BioS 422 Molecular Cell Biology II. Additional courses to reach 24 credits are chosen from upper level electives in molecular biology, cell biology, and biochemistry.

Facilities available for research in the biological sciences include core facilities with equipment (for example, for DNA synthesis, digital imaging, chromatography, cell culture, centrifugation, controlled environments, and scintillation counting). Individual research laboratories and advanced teaching laboratories contain a variety of additional equipment. Ongoing interactions with a variety of private companies contribute additional opportunities for student experiences.

Graduate Courses in the Biological Sciences
BioS 404. (Psy 404) Behavioral Neuroscience (3)
Theoretical and empirical issues in biopsychology. Prerequisite: Graduate standing or consent of instructor.

BioS 405. Special Topics in Molecular Biology (1-3)
Research, conferences, and reports on selected topics not covered in the general graduate offerings. May be taken more than once for credit.

BioS 406. Molecular Biological Seminar (1)
An advanced seminar in current developments including departmental research. Required for candidates for graduate degrees in molecular biology. May be taken more than once for credit.

BioS 407. Research in Biological Science (1-9)
Laboratory investigations in one of the department's research areas.

BioS 408. Responsible Conduct of Science (0)
Responsible practice in research. Training in general laboratory methods; human subjects concerns; radiation safety; chemical hazards; aseptic technique; physical, mechanical, biological, and fire hazards; animal welfare. Occupational and workplace considerations. Recombinant DNA guidelines; patent and proprietary rights; controversies over applications of science. Appropriate aspects required of investigators in all departmental research projects.

BioS 409. Evolutionary and Functional Morphology (3)
Readings in the current literature, demonstrations and laboratory exercises exploring the applications of comparative methods to the analysis of evolutionary patterns at a range of morphological levels (molecular and macroscopic). Students will also learn experimental approaches to testing relationships between form and function in vertebrates. Emphasis will be on the muscular and nervous systems. Prerequisite BioS 134 Comparative Vertebrate Anatomy, BioS 317 Evolution, and EES 361 Animal Physiology or permission of instructor.

BioS 410. Special Topics in Behavioral and Evolutionary Biology (1-3)
Readings and discussions on selected topics not covered in the general graduate offerings. May be taken more than once for credit.

BioS 411. Advanced Cell Biology (3)
Cell structure and biochemistry, as related to specialized cell functions.

BioS 412. Metabolic Influences on Behavior (3)
Sensory systems that detect metabolic energy availability and affect the behavior of humans and other animals: food intake and body weight regulation, sexual and parental behavior, aggression, learning, and body temperature regulation. Prerequisite BioS 404 and consent of instructor.

BioS 414. Sexual Differentiation (3)
Genetic and hormonal events mediating the development and expression of sexual dimorphisms in physiology and behavior. Current theoretical models; emphasis on biochemical, neuroanatomical and molecular biological considerations. Prerequisite: BioS 404 and consent of instructor.

BioS 415. Neuropharmacology (3)
Mechanism of drug action in the central nervous system, including cell surface receptors and second messenger systems. Drug use/abuse and cellular changes mediating behavioral effects. Drug use in clinical therapy. Prerequisite: BioS 404 and consent of instructor.

BioS 418. Analysis of Reproduction and Mating Systems (3)
Study of reproduction and sexuality in plants and animals with emphasis on current hypotheses as reported in the literature. Topics include hermaphroditism, neoteny, larval forms, parental investment, complex life cycles, population structure. Readings from primary source material and review articles. One review paper and one research proposal are required, and together with readings forms the basis for discussion sections and examinations. Prerequisite: Consent of the department chair.

BioS 419. Bacterial Genetics (3)
Structure and function of genetic information in prokaryotes. Composition, size, and organization of chromosomes and accessory elements; mechanisms of replication, recombination, transmission, and mutation; variation within and among strains.

BioS 420. Pheromonal Communication (3)
Mechanisms of pheromone synthesis, biochemistry, sensory transduction, neuroanatomy, and adaptive significance. Prerequisite: BioS 404 and consent of instructor.

BioS 421. Molecular Cell Biology I (3)
Molecular aspects of cell structure, cell motility, intracellular transport, and biomembrane dynamics. Prerequisite: BioS 411 or equivalent.
BioS 422. Molecular Cell Biology II (3)
Molecular aspects of gene expression, including genome structure and replication, RNA synthesis/processing, and protein synthesis. Prerequisite: BioS 345 or equivalent.

BioS 425. Male Reproductive Biology (2 or 3)
Molecular, cellular, and genetic aspects of the mammalian male reproductive system. Prerequisite: BioS 367 or equivalent.

BioS 427. Techniques in Cell and Molecular Biology (3)
Laboratory experiences in three or more cell and molecular biological techniques: gel electrophoresis of nucleic acids/proteins; polymerase chain reaction; DNA/RNA sequencing; molecular hybridization techniques; fluorescence microscopy; video enhanced microscopy; flow cytometry; electron microscopy tissue preservation; immunological detection methods; molecular cloning techniques; oocyte microinjection techniques; tissue culture methods; and autoradiography.

BioS 429. Advances in Herpetology (3)
Lectures and readings from the primary literature on current research in amphibian and reptilian biology. Two lectures, one discussion session and one laboratory or field trip. In addition, a week-long field trip during spring vacation is required. Not open to students who have received credit for BioS 329.

BioS 431. Advanced Topics in Cell Biology (3)
Current research problems in cell biology. May be repeated when a different topic is offered. Prerequisite: BioS 367 or equivalent.

BioS 432. Advanced Topics in Molecular Genetics (3)
Current research in molecular genetics. May be repeated when a different topic is offered. Prerequisite: BioS 345 or equivalent.

BioS 433. Advanced Topics in Developmental Biology (3)
Current research problems in developmental biology. May be repeated when a different topic is offered. Prerequisite: BioS 345 or equivalent.

BioS 437. (Chm 437) Pathophysiological Chemistry (3)
Biochemical basis of human diseases involving abnormal metabolism of proteins, nucleic acids, carbohydrates, and lipids. Emphasis on the correlation of the clinical presentation of disease processes seen as physiological dysfunctions with clinical laboratory methods. Lectures, student presentations, and clinical case discussions. Prerequisite: consent of the department chair.

BioS 439. Advanced Behavioral Ecology (3)
Critical evaluation of the theoretical foundation in sociobiology. Emphasis placed on kinship, altruism, mate choice, parental investment, parent-offspring conflict, etc. Lectures and seminars. Prerequisite: BioS 317 Evolution or equivalent. Not open to students who have taken BioS 337.

BioS 445. Systematics and Evolution (3)
Theoretical, philosophical and methodological foundations of the classification of eukaryotic organisms and the manner in which systematic theory and method relate to evolutionary theory. Two lectures and one lab-recitation-discussion session. Prerequisite: BioS 317.

BioS 453. General Neuroanatomy (3)
Graduate level study of the neuroanatomy and neurochemistry of systems that underlie behavior in vertebrates. Emphasis will be on the traditional and novel methodologies used to reveal neuroanatomical pathways as well as the function of these pathways. Prerequisites: BioS 177 Introduction to Behavioral Neuroscience and BioS 375 Neuroanatomy of Behavior or permission of instructor.

BioS 457. Advanced Behavioral Neuroendocrinology. (3)
A seminar course that covers current primary literature on the hormone-nervous system interactions that underlie physiology and behavior. The course covers the neuroendocrinology of reproduction, sex behavior, parental behavior, social behavior, agonistic and territorial behavior, learning and memory, homeostasis (caloric, nutritional, water and salt balance, temperature regulation), circadian rhythms and seasonality in a variety of vertebrates. Prerequisite: BioS 382 or permission of instructor.

BioS 463. Advances in Plant Molecular Biology (3)
Gene expression and molecular biology of plant systems. Biochemistry of photosynthesis and chloroplast development; higher plant developmental genetics; plant/microbe interactions; plant viruses; advances in genetic engineering in plants. Prerequisite: BioS 345 or equivalent.

BioS 464. Molecular Biology of Eukaryotic Organisms (3)
Comparative analysis of several eukaryotes as model systems in cell biology, developmental biology, genetics, and molecular biology. Prerequisite: BioS 345 or equivalent.

BioS 466. Structure and Function of RNA and Ribonucleoprotein Complexes (3)
Biochemistry and function of small nuclear RNPs, RNase P, ribosomes, self-splicing introns, signal recognition particle, RNA viruses. Functions of RNA in DNA replication, in regulation, as an enzyme, and as a repressor. Prerequisite: BioS 345 or equivalent.

BioS 467. (Chm 467) Principles of Nucleic Acid Structure (3)
alternate years
An examination of the principles underlying nucleic acid structure including stereochemistry, hydration, torsional constraints, sequence specific effects, and interaction with nuclear proteins. Special emphasis will be placed on RNA structure. Prerequisites: one year of biochemistry and one year of physical chemistry or permission of the department chair.

BioS 468. (Chm 468) Principles of Protein Structure (3)
alternate years
An examination of the principles underlying protein structure including stereochemistry, preferred tertiary structures, protein homology, excluded volume effects, time dependent structural fluctuations, and prediction of protein structure from sequence information. Prerequisites: one year of biochemistry and one year of physical chemistry or permission of the department chair.

BioS 469. (Chm 469) Biochemical Problem Solving I (1) fall
Applications of material covered in BioS/Chm 371 including techniques used in research. Prerequisite: BioS/Chm 371 previously or concurrently.

BioS 470. (Chm 470) Biochemical Problem Solving II (1) spring
Applications of concepts covered in BioS/Chm 372 including techniques used in research. Prerequisite: BioS/Chm 372 previously or concurrently.

BioS 471. (Chm 471) Eukaryotic Biochemistry (3)
alternate years
Biochemistry of selected eukaryotic processes including hormone chemistry, blood clotting, immunology, vision chemistry, muscle chemistry and photosynthesis. The second part of the course will involve presentation and discussion of the current literature by class participants. Prerequisite: BioS/Chm 372 or consent of department chair.

BioS 472. (Chm 472) Lipids and Membranes (3) alternate years
Structure, physical properties and functions of lipids and their biological aggregates. Techniques for studying lipid assemblies, enzymes which act on lipids, membrane proteins and lipoproteins will also be discussed. Prerequisite: BioS/Chm 372 or consent of department chair.
BioS 473. (Chm 473) Biochemistry of Complex Carbohydrates (3) alternate years
Consideration of the structure, function and metabolism of complex carbohydrates (glycolipids, glycoproteins and proteoglycans) with particular emphasis on glycoproteins. The first part of the course will consist of lectures to familiarize the student with basic terms, concepts and processes. The second part will involve critical readings, presentation and discussion of the current primary research literature by class participants.

BioS 477. (Chm 477) Topics in Biochemistry (1-3)
Selected areas of biochemistry, such as mechanisms of enzyme action, new developments in the chemistry of lipids, nucleic acids, carbohydrates and proteins. May be repeated for credit when different topics are offered. Prerequisite: consent of the department chair.

BioS 479. (Chm 479) Biochemical Techniques (3)
Laboratory studies of the techniques and principles involved in the isolation, identification, and biochemical transformation of carbohydrates, lipids, nucleic acids and proteins. Prerequisite: BioS 371 or its equivalent previously or concurrently.

BioS 480. (Chm 480) Advanced Biochemical Preparations (1-3)
An advanced laboratory course in the preparation, isolation, purification, and identification of biochemically produced materials. Emphasis is placed on materials and procedures of current interest in biochemistry. Prerequisite: consent of the department chair.

BioS 483. Special Topics in Behavioral Neuroscience (3)
Examination of the biological substrates of behavior. Topics may include animal communication, sociobiology, behavioral endocrinology, or behavior genetics. May be repeated for credit. Prerequisite: BioS 404 or consent of department.

BioS 488. Seminar in Neuroscience, Behavior, and Evolution (1)
Advanced seminar in current research developments. May be taken more than once for credit.

Business Information Systems

Business Information Systems

BioS 473. (Chm 473) Biochemistry of Complex Carbohydrates (3) alternate years
Consideration of the structure, function and metabolism of complex carbohydrates (glycolipids, glycoproteins and proteoglycans) with particular emphasis on glycoproteins. The first part of the course will consist of lectures to familiarize the student with basic terms, concepts and processes. The second part will involve critical readings, presentation and discussion of the current primary research literature by class participants.

BioS 477. (Chm 477) Topics in Biochemistry (1-3)
Selected areas of biochemistry, such as mechanisms of enzyme action, new developments in the chemistry of lipids, nucleic acids, carbohydrates and proteins. May be repeated for credit when different topics are offered. Prerequisite: consent of the department chair.

BioS 479. (Chm 479) Biochemical Techniques (3)
Laboratory studies of the techniques and principles involved in the isolation, identification, and biochemical transformation of carbohydrates, lipids, nucleic acids and proteins. Prerequisite: BioS 371 or its equivalent previously or concurrently.

BioS 480. (Chm 480) Advanced Biochemical Preparations (1-3)
An advanced laboratory course in the preparation, isolation, purification, and identification of biochemically produced materials. Emphasis is placed on materials and procedures of current interest in biochemistry. Prerequisite: consent of the department chair.

BioS 483. Special Topics in Behavioral Neuroscience (3)
Examination of the biological substrates of behavior. Topics may include animal communication, sociobiology, behavioral endocrinology, or behavior genetics. May be repeated for credit. Prerequisite: BioS 404 or consent of department.

BioS 488. Seminar in Neuroscience, Behavior, and Evolution (1)
Advanced seminar in current research developments. May be taken more than once for credit.

Business

The designation of “business” refers to general business courses.

Undergraduate Courses
BUS 1. Introduction to Business (2)
An introduction to business, emphasizing critical issues impacting the business world, such as globalization, technology, ethics, and diversity. Provides an overview of the various functional areas of business and how they fit together. Stress experiential learning and develops team-building skills. Strengthens written and oral communications skills. Will be offered only in the fall and is open only to College of Business and Economics freshmen.

BUS 2. Introduction to Business II (2)
Introduction to career opportunities and curriculum choices in business and economics. Students will learn about the business profession and the characteristics needed for success in the business world through a series of lectures by faculty and guest speakers. Students will work on a project designed to help them understand the integration of the business disciplines of accounting, economics, finance, business information systems, management and marketing. Will be offered only in the spring.

BUS 3. Computer Basics I (1)
A survey of computer software applications in business and economics, including use of operating systems and the World Wide Web, presentation software, and spreadsheets. BUS 3 is a prerequisite for many courses in the CBE. One credit for grade.

BUS 4. Computer Basics II (1)
A survey of computer software applications in business and economics, including use of data base management systems and computer programming. BUS 4 is a prerequisite for many courses in the CBE. One credit for grade. Prerequisite: BUS 3

BUS 201. (Engr 101) Integrated Product Development Projects (3)
Business, engineering and design arts students work in cross-disciplinary teams of 4-6 students on marketing, financial and economics planning, economic and technical feasibility of new product concepts. Teams work on industry projects with faculty advisors. Oral presentations and written reports. Open to junior or senior students in business, economics or arts.

Business Information Systems

The information systems major requires four courses and two electives beyond the core requirements of the College of Business and Economics. Students are required to take BIS 211, Management Information Systems, as part of the business and economics core. Other courses are as follows:

Required Courses (4):
Csc 177. Structured Programming and Data Structures (4)
Csc 241 or IE 224. Information Systems Analysis and Design (3)
BIS 311. Managing Information Systems Development (3)
Mgt 311. LUMAC Management Assistance Counseling (3)
Mgt 321. Business Information Systems Practicum (3)
Mgt 373. Business Information Systems Internship (1-3)

Elective Courses (Choose 2):
Acct 311. Accounting Information Systems (3)
Csc 262. Programming Languages (3)
Csc 330. Advanced Software Engineering Tools (3)
ECE 216. Software Engineering (3)
IE 341. Data Communication Systems Analysis and Design (3)
Mgt 302. Quantitative Models - Conceptual (3)
BIS 331. Electronic Commerce and Security (3)

Consult Professor Sherer for other related courses.

Undergraduate Courses
BIS 211. Management Information Systems (3)
This course examines the role of information and information systems in business organizations. Computer-based information systems play a fundamental role in data processing, management decision support, manufacturing/production
control, and internal and external reporting. This course integrates system concepts, organization theory, decision-making, and technology critical to the understanding of routine business applications and the strategic use of information systems. Prerequisite: Acct 152.

BIS 311. Managing Information Systems Development (3)
Managing the development and implementation of information systems for business. Project management for business systems implementation, business systems analysis and design. Implementation of custom-designed as well as packaged systems. Cost benefit analysis and risk management of systems implementation. Prerequisites: BIS 211 or Acct 311 or consent of instructor.

BIS 331. Electronic Commerce and Security (3)
This course covers how businesses, the government and consumers use the Internet to exchange information and initiate transactions. Topics include risks of insecure systems, Internet security standards and protocols, cryptography, authentication and digital signatures, website attestation and assurance, firewalls, electronic cash systems, electronic legal agreements and international cryptographic restrictions. Students will get hands-on experience designing security-conscious web sites using FrontPage 98. Prerequisite: BIS 211 or Acct 311 or consent of instructor.

BIS 360. Business Information Systems Practicum (3)
The business information systems practicum provides an opportunity for students to work on an intensive consulting engagement with a business. Students work with client firms on individual or team projects, which focus on information systems activities such as developing requirements, designing, and implementing systems. Students complete written reports and make formal presentations to clients. May not be taken concurrently with Mgt 311. Prerequisites: Junior standing in the College of Business and Economics.

BIS 371. Directed Readings (1-3)
Readings and research information systems; designed for superior students who have special interest in some topic(s) not covered by the regularly scheduled courses. Written term paper(s) required. May be repeated. Prerequisite: preparation in information systems acceptable to program coordinator.

BIS 372. Special Topics (1-3)
Special problems and issues in information systems for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of the instructor and students. May be repeated. Prerequisite: preparation in information systems acceptable to program coordinator.

BIS 373. Business Information Systems Internship (1-3)
Based upon a student's work experience, a sponsoring faculty member shall direct reading, projects and other assignments - including a "capstone report." It should be noted that the work experience, by itself, is not the basis for academic credit. The faculty-directed activity may be provided concurrent with the work or as a follow-up to the work experience. In the latter case, arrangements must be made in advance of the work engagement so as to enhance the follow-up experience (keeping logs, concurrent reading assignments, etc.). Student effort is expected to be at least 40 hours per credit. Prerequisites: Csc 17, IE 224 or Csc 241, junior standing in the College of Business and Economics.

Course descriptions for the College of Business and Economics graduate courses can be found in this section (Section V) under the heading of Business and Economics Graduate Courses.

Business and Economics Graduate Courses

MBA Prerequisites
GBUS 401. Financial Reporting for Managers and Investors (3)

GECO 401. Basic Statistics for Business and Economics (3)
Descriptive statistics, probability and probability distributions, estimation, hypothesis testing, correlation and regression, chi-square analysis and analysis of variance. Computer applications.

MBA Program Core Courses
MBA 401. Introduction to the Organization and its Environment (1)
An MBA core course which introduces the entering MBA student to the workings of today's organization and how it impacts and is impacted by its environment. These concepts will be exposed by using the integrated value chain model and applied through the analysis of a comprehensive case. The course will be offered over a two-day period at the beginning of each semester.

MBA 402. Managing Financial and Physical Resources (4)
An MBA core course designed to integrate financial and managerial concepts into operations decisions. Disciplines of accounting, finance and economics are combined to provide substantive foundations for discussing and analyzing data. Implications of analysis are applied to facilitate decision-making in other areas such as marketing, operations (manufacturing, logistics and engineering), human resources, information technology and general management. The major learning objectives will be applied through a series of "living" cases that are centered on analyzing historical financial performance, preparing a business plan, and valuing a business. Prerequisites: MBA 401, GBUS 401 or equivalent.

MBA 403. Managing Information (4)
An MBA core course dealing with concepts and methods involved in the collection, organization and dissemination of information that helps managers make operational and strategic decisions. The course also deals with attributes of information and examines enterprise-wide impacts of local decisions. Revenue, cost, time and quality-based information are accorded equal emphasis, while students are exposed to alternative evaluation methods for decisions related to different parts of the value chain. Topics include: activity-based costing; activity-based management; transaction analysis; operational and strategic decisions such as outsourcing, design partnerships, etc.; investment analysis for short life-cycle investments; evaluation of uncertainty, risk and ambiguity; metrics development; compensation policies; segment evaluation methods; target costing and functional analysis; quality function deployment; total cost of ownership; and transfer pricing. In addition, the course deals with: information technology enablers which allow firms to improve value delivered to customers; and evaluation and management of emerging forms of cooperation, such as joint ventures and project based strategic alliances. Prerequisites: MBA 401, GBUS 401 and GECO 401 or equivalents.

MBA 404. Managing Products and Services (4)
An MBA core course focusing on the management of products and services within a firm's value chain. The course addresses exceeding customer expectations, establishing total quality as the core foundation, developing a strong customer focus, creating
value through supply chain management, developing new products for competitive advantage, matching aggregate supply with customer demand, and designing market channels and influencing customers. Prerequisite: MBA 401.

**MBA 405. Managing People (4)**
An MBA core course that examines how effective organizations are created, maintained, and improved. The course will focus on how good people are attracted to an organization and how to make them productive. Topics include: organizational design, job design, staffing, training and development, performance, teams, influence, diversity, change, ethical decision-making, and current people issues facing today's organizations. The course includes a comprehensive simulation (to be conducted on a Saturday during the semester) and a group project which allows students to apply the principles and concepts covered in the course. Prerequisite: MBA 401.

**MBA 406. Integrative Experience (1-4)**
An MBA core course requirement which provides alternative methods for students to apply the body of knowledge acquired in MBA 401 through MBA 405. Students will have the choice of taking a case course, developing and working on a project through their employer or with a corporate partner, an internship or other suitable experiential learning. The preferred option is an outside project rather than a case course. The academic rigor and time required to complete the project or course will determine the number of credits earned.
Prerequisites: MBA 401, MBA 402, MBA 403, MBA 404, MBA 405

The following courses are core courses in the previous (traditional) MBA Program and may not be used in the MBA Program starting Fall 1998.

**GBUS 404. Information Systems for Managers (3)**
The emphasis of the course is on information system (IS) topics that most directly affect operations level managers. The topics covered include: transactions cycles, management's responsibility for establishing internal controls, alternative technologies for transaction processing, database management systems, distributed data processing and networks, end-user computing, management reporting systems and advanced systems technologies including Decision Support Systems, Expert Systems and Neural Networks. The course follows a lecture and mini-case format. Students work in teams to design an information system for a term project. Prerequisites: GBUS 401 and GBUS 405 or concurrently.

**GBUS 405. Organizational Behavior and Management (3)**
Interpersonal and group behavior in organizations, issues of organization work and perception, motivation, communications, conflict dynamics, leadership and organization structure.

**GBUS 406. Financial Management (3)**
Introduction to financial management. Topics include: financial statement analysis, capital budgeting, capital structure, valuation, risk analysis and working capital management. Prerequisites: GBUS 401 and GECO 402.

**GBUS 407. Managerial Accounting and Decision-Making (3)**
Traditional and emerging techniques of product costing, managerial accounting techniques for planning, control and decision-making, manufacturing and operational performance measures; quality management; cost management by process redesign. Prerequisite: GBUS 401 or equivalent.

**GBUS 408. Marketing Management (3)**
Planning and managing marketing activities: market analysis, buyer behavior, market segmentation, marketing research, product policy and strategy, distribution channels policy, advertising and sales-force management. Prerequisite: GECO 402 (or concurrently).

**GBUS 409. Strategic Information Systems (3)**
Study of the impact of information technology on business competition, organizational structure, and nature of work. Explores development and management of information systems strategy, including economics and risks associated with investments in information systems technology. Case studies and applications include operations management, financial services, and marketing and distribution.

**GBUS 410. Operations Management (3)**
Understanding the forces or trends affecting operations management along with the tools and systems that directly support operations managers. Topical coverage includes understanding manufacturing and service excellence, sources of competitive advantage, total quality management, just-in-time manufacturing, cross functional integration, manufacturing planning activities, inventory control, forecasting, project management, new product development, process design, and competitive requirements for future success. Special emphasis placed on the linkages between operations and other functional areas. Prerequisite: GBUS 403 or equivalent.

**GBUS 411. Managerial Policy and Decision-Making (3)**
Study of the processes used to develop strategic intent and organizational mission; environmental and competitive analysis; strategy formulation and implementation. Contemporary readings, group exercises, and case studies.

**Accounting Electives**

**GBUS 413. Advanced Management Accounting (3)**
Issues in management accounting including activity-based costing, activity based management, strategic cost management, theory of constraints, advanced manufacturing technologies, cost of quality and life-cycle costing. Readings and cases. Prerequisite: MBA 403 / GBUS 407 or a course in cost accounting.

**GBUS 414. Financial Statement Analysis and Interpretation (5)**
This course focuses on analysis of financial statements. It develops the skills necessary to interpret and use financial statement information effectively to assess profitability and risk and is intended for individuals likely to become intensive users of financial accounting information. Requirements include readings, case studies, presentations, and written analysis of actual financial statements. Prerequisite: GBUS 401 and MBA 402 or permission of the instructor.

**GBUS 415. Contemporary Issues in Financial Reporting (3)**
Corporate financial reports from the perspective of the user-analyst; disclosure, price-level accounting, foreign currency, business combinations, leases and analysis of financial statements. Case studies. Prerequisite: GBUS 407 or MBA 402 and 403.

**GBUS 416. Accounting Theory and Thought (3)**
Critical and historical examination of modern accounting concepts. Measurement, communication, and interpretation of enterprise income, capital and related economic data. Prerequisite: 15 credit hours of accounting.

**Law Electives**

**GBUS 402. Legal Environment of Management (3)**
The effect of public and private law on business decisions. The legal relationship of business and society and business and government, especially the government regulation of business. Introduction to contract law underlying the free market system.

**GBUS 437. Federal Taxation and Business Decisions (3)**
Impact of federal taxation on the structure and timing of business decisions. Problem-solving methods and research techniques from a managerial perspective. Prerequisite: GBUS 401 or a basic course in accounting.
Finance Electives

GBUS 420. Investments and Portfolio Management (3)
A survey course in investments. Mostly from the perspective of the institutional investor, but consideration given to corporation finance and personal investing. Topics include: valuation, risk management, and portfolio theory. Course includes exposure to software and databases used by "Wall Street" professionals. Prerequisite: GBUS 406/MBA 402.

GBUS 421. Advanced Investments: (descriptor to change each time course is offered) (3)
Advanced topics relating to specific areas of investment such as: theoretical and empirical examination of recent developments in portfolio theory; risk preferences, inflation, and market conditions; global investing. The course content may vary between instructors and over time. Prerequisite: GBUS 420.

GBUS 422. Options and Financial Futures (3)
An examination of the theory and applications of a variety of derivative instruments used in corporation finance, banking and investments. Topics include: forward contracts (including swaps and options), futures contracts, and options (listed, over-the-counter, and embedded). Prerequisite: GBUS 420.

GBUS 424. Advanced Topics in Financial Management: (descriptor to change each time course is offered) (3)
Advanced topics relating to specific areas of corporate finance such as: theoretical and empirical examination of recent developments in financial management; asset valuation and capital budgeting including the role of uncertainty, imprecise forecasts, risk preferences, inflation, market conditions, and the global marketplace; working capital management, leasing, mergers, and financing. The course content may vary between instructors and over time. Prerequisite: GBUS 406/MBA 402.

GBUS 425. Real Estate Financing and Investing (3)
An upper-level course in modern real estate financing techniques from the perspectives of both the borrower and the lender. Subject matter encompasses the following areas: The Principles of Financing Decisions; Financing Methods and Techniques; Institutional Sources of Funds for Real Estate; and Real Estate Financing Decisions. Students are assumed to have a background in the basics of finance, micro and macroeconomics, statistics and quantitative analysis. The course consists of: lectures, demonstrations, software applications, and practitioner presentations.

GBUS 426. Financial Management of Financial Institutions (3)
Asset and liability management of commercial banks, savings and loan associations, life insurance companies, and pension funds. Short and long-run responses to changes in economic conditions, interest rates and regulation. Prerequisite: GBUS 406/MBA 402.

GBUS 427. (GECO 427) Banking and Monetary Policy (3)
Analysis of the U.S. monetary and banking systems. Financial markets. Central bank controls. Monetary theory and policy. Prerequisite: GECO 403 or equivalent.

GBUS 428. (GECO 428) Capital and Interest Theory (3)
Theories of interest and capital. Annuities, applications of present value theory, investment valuation under uncertainty and risk, term structure of interest rates, the theory of savings, cost of capital and capital formation. Prerequisite: GBUS 406/MBA 402 or equivalent.

GBUS 429. (GECO 429) Monetary Theory (3)
The role of money in the economy from theoretical and empirical perspectives. The influence of money and prices, interest rates, output and employment. Prerequisite: GECO/GBUS 427 or equivalent.

GBUS 430. (GECO 430) Public Finance (3)
The economics of public spending and taxation, principles of government debt management, theories of budgeting and cost-benefit analysis, and public choice.

GBUS 431. Quantitative Financial Models (3)
Relationship of quantitative models to financial theory and applications. Capital budgeting, portfolio selection, security evaluation, cash management, inventory policy and credit analysis. Prerequisite: GBUS 406/MBA 402.

Management Electives - Organizational Behavior

GBUS 440. Human Resource Management (3)
A survey of personnel management activities in organizations. Topics include human resource planning, recruitment, selection, equal employment opportunity, performance appraisal, compensation, career planning, safety and health, and quality of work life issues. Course consists of lectures, discussion, and case analysis.

GBUS 441. Organizational Design and Change (3)
Variables relevant to determining the design of structures and processes of organizations; techniques pertinent to organizational adaptation to changed environments, technologies and social factors. Prerequisite: GBUS 405/MBA 405.

GBUS 442. Seminar in Management Consulting (3)
A study of consulting practices in general and their application to small business. Processes include a field study/counseling service to a local business. Emphasis is on the identification and analysis of multidisciplinary problems and opportunities and the implementation of recommendations. Prerequisites: completion of MBA background courses (or equivalent) and permission of the instructor.

GBUS 443. Managing Organizational Cultures and Diversity (3)
Examines the major issues and dilemmas facing American corporate enterprise as human diversity in the workplace rises sharply over the next decade due to new cultural populations and lifestyles emerging in the domestic workforce. Closely examined are the organizational challenges of developing managerial leadership styles that focus on both quality management outcomes as well as quality of work life and the overall organizational culture. The course combines speakers from diverse “interest groups” with reflective seminar readings, group writings and class discussions. Position papers and a final paper synthesizing the interactive experience with the seminar learning is required of each participant. Prerequisite: GUS 405/MBA 405 and 2 or more years of work experience preferred.

GBUS 444. Managerial Communication Skills (3)
Organization, style and strategy of language to inform, direct and persuade. Application of writing, reading, speaking and listening skills to managerial problems. Case studies.

GBUS 445. Labor-Management Administration (3)
A study of the U.S. system of industrial relations, including the evolution and present status of labor law; union organizing efforts; the strategy of negotiations; the substantive provisions of collective bargaining and the administration of collective agreements. Also considered is the role of unions in the implementation of programs for employee self-management and other workplace innovations.

GBUS 446. Commercial Potential Assessment (3)
A study of the process of bringing an invention to market with emphasis on commercial potential. Industrial analysis, competitor intelligence and strategic issues will be emphasized along with the development of market strategy and an overall business plan. Extensive research including data base searches will be included. Instructor permission required.
Management Electives - Operations Research and Analytical Management

GBUS 403. Quantitative Methods in Business and Economics (3)
Management science methods and applications are emphasized for problems of determining the best allocation of scarce resources for product mix, facility location, inventory control, portfolio analysis, customer service, vehicle routing, and scheduling production and distribution. Lectures and case studies are used to illustrate various management science methods such as mathematical programming, simulation, decision theory, game theory, network models and statistics. Prerequisite: GECO 401 or equivalent.

GBUS 450. Strategic Supply Management (3)
A survey course designed to introduce the MBA / MSE student to the vital role played by supply management in achieving overall effectiveness for the firm in today's global economy. The course starts by examining the traditional purchasing process and then moves on to an examination of the evolution of purchasing into supply management and, finally, to the role purchasing plays in improving effectiveness of the entire value chain. Course consists of lectures, discussion and case analysis.

GBUS 451. Analytical Methods in Management (3)
Application of management science methods to industrial and commercial problems. Scientific method, decision theory, linear programming, inventory control, regression analysis, forecasting, simulation, and related areas are examined in the context of accounting, finance, marketing and manufacturing.

GBUS 452. [IE 417] Advanced Mathematical Programming (3)
Theory and applications of the extensions of linear programming, Tucker-Kuhn conditions, gradient methods of optimization, simplex-based methods of nonlinear programming, integer programming, branch and bound, zero-one discrete programming and stochastic programming. Prerequisite: a course in linear programming.

Marketing Electives

GBUS 460. Strategic Marketing (3)
The roles of customer functions served, customer groups served and technologies utilized in defining their business are considered. Students perform a marketing audit and develop a marketing plan. Prerequisite: GBUS 408 / MBA 404.

GBUS 461. Advertising and Promotion Management (3)
A broad overview of managerial decisions involved in developing, planning, presenting, and implementing advertising and promotional activities for business and not-for-profit organizations. Analysis of current campaigns and a term project are semester assignments. Prerequisite: GBUS 408 / MBA 404.

GBUS 462. Buyer Behavior and Marketing Management (3)
Concepts, methodologies and current research involving consumer and organizational buying behavior. Prerequisite: GBUS 408 / MBA 404.

GBUS 463. Management of Sales Operations (3)
Planning and organizing strategic sales programs; developing the sales force through recruitment, training and motivation; control of sales programs through performance evaluation and integrating sales with other marketing activities. Prerequisite: GBUS 408 / MBA 404.

GBUS 464. Industrial Marketing and Sales Management (3)
Marketing and sales problems associated with manufacturers of industrial products: organization and productivity of the sales force, product-line policies, pricing strategies, buyer requirements, customer service and formal proposals. Prerequisites: GBUS 406 / MBA 402 and GBUS 408 / MBA 404.

GBUS 465. New Product Planning in Marketing and Research and Development (3)
Analysis of problems associated with developing and marketing new products and processes in technologically-oriented enterprises, from inception of idea to planning marketing strategies. Prerequisites: GBUS 406 / MBA 402 and GBUS 408 / MBA 404.

GBUS 466. Marketing Information and Decision-Making (3)
Obtaining relevant marketing information for decision-making is examined from two perspectives: special projects and information systems. Student projects. Prerequisite: GBUS 408 / MBA 404.

GBUS 467. Causal Modeling (3)
This course brings together a single analytical framework and two longstanding traditions: simultaneous equation modeling (regression analysis) and factor analysis (measurement models). Topics covered include measurement error, reliability, validity, confirmatory factor analysis, and latent variable modeling. Prerequisite: intermediate statistical theory or consent of department chair.

GBUS 468. Research Methodology (3) (Doctoral students only.)
Criteria which distinguish scientific research from other significant human activities; development of concepts, laws and theories; general principles of research design; measurement theory; and scientific values and ethics. Students are expected to prepare a defensible dissertation proposal during the course.

GBUS 469. Advanced Data Analysis (3)
Applications-oriented analysis of variance, regression analysis and multi-variate analysis. SPSS, BMD and other computer packages are used to analyze empirical data. Prerequisite: intermediate statistics or consent of chair.

International Business Electives

GBUS 473. International Financial Management (3)
Financial management of multinational firms. Consideration of problems arising from diversity of currencies, investment opportunities, risk and international capital markets. Prerequisite: GBUS 406 / MBA 402.

GBUS 474. Legal Aspects of International Business (3)
Various legal problems of engaging in business abroad, including contracts, technology transfer, property ownership, business organizations and labor, using a case and problem-solving approach.

GBUS 475. Marketing and the Global Firm (3)
Emphasis is placed on understanding the process of globalization and its resultant impact on the firm's marketing function. Case analyses and/or computer simulations are employed to enhance the student's understanding of the challenges and opportunities facing the firm pursuing globalization. Prerequisite: GBUS 408 / MBA 404.

GBUS 476. Globalization and Management of Technology (3)
Management of science and technology in the context of international business and the globalization of markets, competition and corporations. Management of Global industrial R & D; technology-based global strategic alliances; global external technology sourcing, complex human resources and cross-cultural issues, etc. Develops an appreciation of the scientific and technical capabilities available globally and the potential for global cooperative and/or competition in this regard.

Management of Technology Core Course and Electives

GBUS 480. Technology Management Seminar (3)
Review of current literature on technology management with emphasis on the relationships among business strategy, competitive conditions, management practice and the
technological innovation process. Case studies and outside speakers. Critical analysis of research and application to technology management problems.

GECO 481. Technology, Operations and Competitive Strategy (3)
Develops an understanding and appreciation of the interrelationships among technology, operations and the competitive strategy of the firm. Industry analysis and competitiveness; competitive strategy formulation and implementation; value chain analysis; operations strategy and technology strategy; operation's contributions to competitive advantages in cost, quality and variety and new product introduction.

GBUS 482. R, D & E Project Management (3)
Management of cross-functional project teams for introducing technological innovations in the manufacturing and marketing of new products and services in a variety of industries.

GBUS 483. R & D Management (3)
Developing R&D programs to achieve strategic business objectives; selecting, staffing and managing R&D projects; and transferring research results to commercial functions.

GBUS 484. Science and Technology Policies and Institutions (3)
The science and technology institutional infrastructure and its relationships with management decision-making, including private, public (government) and quasi-public institutions; R&D, regulatory, and policy institutions; and U.S., foreign and international institutions.

GBUS 485. Diffusion and Implementations of Technology (3)
Classical macro-study of adoption and diffusion of innovation, and managing the implementation / utilization / application of new technology in the organization / corporate culture.

GBUS 486. Qualitative Research Methodology (3)
Study of techniques that describe, decode and translate social phenomena. Explores how interpretive researchers plan and conduct studies and present findings. Studies investigators’ roles, data sources, observation methods, data-analysis methods and trustworthiness of findings. A field research project is required.

Economics
Ph.D. Required Core Courses
GECO 411. History of Economic Thought (3)
Selected topics in the history of economic thought, with special attention to the origins of modern economic theory. Prerequisite: a graduate course in economic theory.

GECO 412. Mathematical Economics (3)
Applications of various mathematical techniques in the formation and development of economic concepts and theories. Prerequisite: consent of the chair.

GECO 413. Advanced Microeconomics Analysis (3)
A survey of methods of decision-making at the microeconomic level; price theory and econometric applications. Prerequisite: GECO 402 or equivalent.

GECO 414. Advanced Topics in Microeconomics (3)
Resource allocation and price determination. Theories of choice of consumers, firms and resource owners under various market forms. Prerequisites: GECO 401 and GECO 413 or equivalents.

GECO 415. Econometrics I (3)

GECO 416. Econometric Theory (3)
Mathematical and statistical specification of economic models. Statistical estimation and tests of parameters in single and multiple equation models. Prediction and tests of structural changes. Prerequisites: GECO 401 (or equivalent) and calculus.

GECO 417. Advanced Macroeconomics Analysis (3)
Macroeconomic theory and policy. Emphasis on theoretical models and policy implications. Prerequisite: GECO 403 or equivalent.

GECO 418. Advanced Topics in Macroeconomics (3)
Models of employment, income and growth in monetary economies. Policies for economic stability and growth. Prerequisite: GECO 417 or equivalent.

Economics Electives
GECO 402. Managerial Economics (3)

GECO 403. Money, Banking and Macroeconomics Analysis (3)
The monetary process and the determination of macroeconomic variables: income, output, employment and prices. Money and capital markets, interest rates, functions of financial intermediaries, monetary and fiscal policy, and recent macroeconomic issues.

GECO 404. Technology, Trade and Economics Growth (1)
(required for MOT and MBA-MOT students only)
Overview of the role of technology in economic systems: Productivity and growth effects, relationships to industry structure, impacts on international trade and competitiveness. Prerequisite: intended to be taken concurrently with GEKO 402.

GECO 427. (GBUS 427) Banking and Monetary Policy (3)
Analysis of the U.S. monetary and banking systems. Financial markets. Central bank controls. Monetary theory and policy. Prerequisite: GECO 403 or equivalent.

GECO 428. (GBUS 428) Capital and Interest Theory (3)
Theories of interest and capital. Annuities; applications of present value theory; investment valuation under uncertainty and risk; term structure of interest rates; the theory of savings, cost of capital and capital formation. Prerequisite: GBUS 406 / MBA 402 or equivalent.

GECO 429. (GBUS 429) Monetary Theory (3)
The role of money in the economy from theoretical and empirical perspectives. The influence of money and prices, interest rates, output and employment. Prerequisite: GECO / GBUS 427 or equivalent.

GECO 430. (GBUS 430) Public Finance (3)
The economics of public spending and taxation; principles of government debt management; theories of budgeting and cost-benefit analysis and public choice.

GECO 436. Economic History of the United States (3)
Analysis of the colonial economy, transition to industrialization, and the role of trade and transportation in America’s development. A consideration of the importance of slavery to the 19th-century American economy and other New World economies. Origin and development of banking and financial markets. Prerequisites: GECO 401 and GECO 402 or equivalents.
The course will focus first on describing the current U.S. energy industry. Pre requisites: GECO 402 and GBUS 403 or CECO 450. Economics of Energy (3)

The economics of energy production and consumption. Energy system modeling for forecasting and planning. Theoretical models of resource exploitation over time. Regulation of the energy industry. Prerequisites: GECO 402 and GBUS 403 or equivalents.

The application of traditional and spatial economics to the location of economic activity focusing on the urban economic problems of business location, housing, land value, land use and intra-urban transportation.

A study of the methodology of regional science with emphasis on metropolitan area analysis. A survey of the applications of this methodology to the economic problems of regions and metropolitan areas.

Analysis of the economic justification for government regulation of private enterprise. Topics include antitrust policy, utilities, and health, safety and environmental regulation. Prerequisite: GECO 402 or equivalent.

Economic theory of natural resources. Optimal policies for the development of renewable and nonrenewable resources and environmental quality. Prerequisite: GECO 402 or equivalent.

Economic theory of health care delivery systems. Financing health care services. Case studies of specific economic-financing problems and/or international comparisons of health care delivery. Prerequisite: GECO 401 or GECO 402 or permission of the instructor.

The goal of the course is to review theoretical and empirical attempts by economists to understand market structures lying between the extremes of perfect competition and monopoly. The course will focus first on describing the current U.S. industrial structure and reviewing models of imperfect competition. The course then shifts to a closer study of individual firm behavior. The final segment of the course is an overview of two significant relationships between government and industry caused by the existence of imperfect competition.

Classical decomposition of time series, trend analysis, exponential smoothing, spectral analysis and Box-Jenkins autoregressive and moving average methods.

Methods of economic and business forecasting.

An expanded development of statistical concepts necessary for business and economic research. Topics include probability theory, sets, density functions and distributions, sampling distributions, point estimation, moment generating functions, maximum likelihood, classical statistical inference, power functions, likelihood ratio tests and non-parametric tests. Prerequisite: calculus.

A mathematical analysis of how people interact in strategic situations. Topics include normal-form and extensive-form representations of games, various types of equilibrium requirements, the existence and characterization of equilibria, and mechanism design. The analysis is applied to microeconomic problems including industrial organization, international trade, and finance. Prerequisites: Two semesters of calculus, GECO 414 and GECO 412, or permission of the instructor.

Foundations of theory construction and empirical research in economics.

Analysis of the structure and functioning of the international monetary system, international capital markets, Eurocurrency markets, fixed and floating exchange rates, and the role of international monetary institutions in foreign exchange risk management.

An introduction to the basic theoretical concepts in international economic development and an evaluation of their application by means of a representative sample of the literature.

Theories of comparative advantage, factor price equalization, trade and welfare, tariffs, trade and factor movements. Prerequisite: GECO 413 or consent of the chair.

Theory of the balance of payments, the microeconomics of international finance, various approaches to balance-of-payments adjustments, theories of foreign exchange-rate determination and macroeconomic policy under fixed and flexible exchange rates. Prerequisite: GECO 417 or consent of the chair.

Explores theoretical models and empirical evidence on the economics of innovation and technical change. Includes examination of: the role of technology in competitiveness, industrial structure and economic growth; alternative models of the innovative process; incentives for and other conditions affecting research and development; the evaluation of the justifications for government support of R&D. Prerequisites: GECO 402.

Mohamed S. El-Aasser, Ph.D. (McGill), chair and Iacocca Professor; Fred P. Stein, Ph.D. (Michigan), associate chair; Philip A. Blythe, Ph.D. (Manchester, England); Hugo S. Caram, Ph.D. (Minnesota); Marvin Charles, Ph.D. (Brooklyn Polytechnic); John C. Chen, Ph.D. (Michigan), Carl R. Anderson Professor; Gregory C. Farrington, Ph.D. (Harvard), president; Christos Georgakis, Ph.D. (Minnesota); James T. Hsu, Ph.D. (Northwestern); Andrew Klein, Ph.D. (North Carolina State); William L. Luiken, Ph.D. (Delaware); Janice A. Phillips, Ph.D. (Pennsylvania); William E. Schiesser, Ph.D. (Princeton), McCann Professor; Arap K. Sengupta, Ph.D. (Houston); Leslie H. Sperling, Ph.D. (Duke); Cesar A. Silebi, Ph.D. (Lehigh); Harvey G. Stenger, Jr., Sc.D. (MIT); Israel E. Wachs, Ph.D. (Stanford).

Manoj K. Chaudhury, Ph.D. (SunyBuffalo), Dow Corning associate professor; Maria M. Santore, Ph.D. (Princeton).
Assistant professor. Mayuresh V. Kothare, Ph.D. (California Institute of Technology).


Research engineers. E. David Sudol, Ph.D. (Lehigh); Kemal Tuzla, Ph.D. (Technical University of Istanbul).

Research scientist. Eric S. Daniels, Ph.D. (Lehigh).


The mission of the undergraduate program is “to educate students in the scientific principles of chemical engineering and provide opportunities to explore their applications in the context of a humanistic education that prepares them to address technological and societal challenges.”

Chemical engineers serve a wide variety of technical and managerial functions within the chemical processing industry. For a lifetime of effectiveness they need a sound background in the fundamental sciences of chemistry and physics; a working capability with mathematics, numerical methods, and application of computer solutions; and a broad education in humanities, social sciences, and managerial techniques.

These bases are applied in a sequence of chemical engineering courses in which logic and mathematical manipulation are applied to chemical processing problems. With the resulting habits of precise thought coupled to a broad base in scientific and general education, Lehigh graduates have been effective throughout industry and in advanced professional education. No effort is made toward any specific industry, but adaptation is rapid and the fundamental understanding forms the base for an expanding career.

The program is also designed to prepare a student for graduate study in chemical engineering. Further study at the graduate level leading to advanced degrees is highly desirable if an individual wishes to participate in the technical development of the field. The increasing complexity of modern manufacturing methods requires superior education for men and women working in research, development, and the design fields or for teaching.

Physical facilities. The chemical engineering department is the only engineering department located on Lehigh’s 780-acre Mountaintop Campus. Here the department occupies approximately one-third of Iacocca Hall, the 200,000-square-foot flagship building that contains offices, classrooms, and laboratories. Additional plant facilities, and the undergraduate chemical processing laboratory occupy approximately 10,000-square-feet in the adjacent Imb building.

These facilities provide excellent support for a wide range of general laboratory equipment for undergraduate study of the behavior of typical chemical processing units; special equipment for biochemical engineering and for the study of polymers; digital computation for process dynamics study; and special equipment for the study of thermodynamics, kinetics, heat transfer, and mass transfer.

The chemical engineering department has established a senior design laboratory in Iacocca Hall featuring 20 Pentium PCs and 5 Octane SGI workstations. In addition, a 10-PC university-maintained computing laboratory is available nearby.

Career Opportunities

Chemical engineers play important roles in all activities bearing on the chemical process industry. These include the functions of research, development, design, plant construction, plant operation and management, corporate planning, technical sales, and market analysis.

The industries that produce chemical and/or certain physical changes in fluids, including petroleum and petrochemicals, rubbers and polymers, pharmaceuticals, metals, industrial and fine chemicals, foods, and industrial gases, have found chemical engineers to be vital to their success. Chemical engineers are also important participants in pollution abatement, energy resources, national defense programs, and more recently in the manufacture of microelectronic devices and integrated circuits.

Special Programs and Opportunities

The department, in conjunction with the College of Engineering and Applied Science, operates a cooperative program that is optional for specially selected students who are entering their junior year. This program affords early exposure to industry and an opportunity to integrate an academic background with significant periods of engineering practice. Our program is unique in offering two work experiences and still allowing the co-op students to graduate in four years with their class.

The Opportunities for Student Innovation (OSI) program seeks to develop the students' propensity for critical assessment and innovative solution of meaningful problems. The OSI program offers selected seniors an opportunity to experience team research leading toward technological benefits. Each project is hosted by a company and carried out under the supervision of a Lehigh faculty member.

Chemical engineering offers specialization certificates in polymer science, biotechnology, and process modeling and control. Technical minors are also available in polymer science and engineering, in materials science and engineering, and in environmental engineering.

Study abroad is available in exchange programs that have been established by the department for the junior year at the University of Nottingham (United Kingdom) and for the summer following the junior year at the University of Dortmund (Germany).

Requirements of the Major

Freshman year (see Recommended Freshman Year)

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>ChE 179</td>
<td>Professional Development (1)</td>
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<tr>
<td>ChE 201</td>
<td>Methods of Analysis in Chemical Engineering (3)</td>
</tr>
<tr>
<td>ChE 210</td>
<td>Chemical Engineering Thermodynamics (4)</td>
</tr>
<tr>
<td>ChE 233</td>
<td>Process Design I (3)</td>
</tr>
<tr>
<td>Chm 187</td>
<td>Physical Chemistry I (3)</td>
</tr>
<tr>
<td>Math 205</td>
<td>Linear Methods (3)</td>
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Sophomore year, first semester (18 credit hours)

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<tr>
<th>Course</th>
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<tbody>
<tr>
<td>ChE 31</td>
<td>Material and Energy Balances of Chemical Processes (3)</td>
</tr>
<tr>
<td>Chm 31</td>
<td>Chemical Equilibria in Aqueous Systems (3)</td>
</tr>
<tr>
<td>Phy 21</td>
<td>Introductory Physics II (4)</td>
</tr>
<tr>
<td>Phy 22</td>
<td>Introductory Physics Laboratory II (1)</td>
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<tr>
<td>Math 23</td>
<td>Calculus III (4)</td>
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Sophomore year, second semester (18 credit hours)

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<tr>
<th>Course</th>
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<tbody>
<tr>
<td>ChE 44</td>
<td>Fluid Mechanics (4)</td>
</tr>
<tr>
<td>ChE 210</td>
<td>Chemical Engineering Thermodynamics (4)</td>
</tr>
<tr>
<td>ChE 179</td>
<td>Professional Development (1)</td>
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<tr>
<td>Chm 187</td>
<td>Physical Chemistry I (3)</td>
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<td>Math 205</td>
<td>Linear Methods (3)</td>
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Junior year, first semester (18 credit hours)

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<tr>
<th>Course</th>
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<tbody>
<tr>
<td>ChE 151</td>
<td>Introduction to Heat Transfer (3)</td>
</tr>
<tr>
<td>Chm 201</td>
<td>Methods of Analysis in Chemical Engineering (3)</td>
</tr>
<tr>
<td>Chm 31</td>
<td>Organic Chemistry I (3)</td>
</tr>
<tr>
<td>Chm 53</td>
<td>Organic Chemistry Laboratory I (1)</td>
</tr>
<tr>
<td>Chm 192</td>
<td>Physical Chemistry Laboratory (2)</td>
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Junior year, second semester (18 credit hours)

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>ChE 242</td>
<td>Introduction to Process Control and Simulation (3)</td>
</tr>
<tr>
<td>ChE 244</td>
<td>Mass Transfer and Separation Processes (3)</td>
</tr>
<tr>
<td>ChE 211</td>
<td>Chemical Reactor Design (3)</td>
</tr>
<tr>
<td>Chm 52</td>
<td>Organic Chemistry II (3)</td>
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Senior year, first semester (16 credit hours)

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<th>Course</th>
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<tbody>
<tr>
<td>Chm 189</td>
<td>Physical Chemistry II (3)</td>
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<tr>
<td>ChE 202</td>
<td>Chemical Engineering Laboratory I (2)</td>
</tr>
<tr>
<td>ChE 233</td>
<td>Process Design I (3)</td>
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</table>

Electives (8)
The total number of credits required for graduation is 134.

There are five types of electives:
(1) Humanities/Social Sciences: See the requirements set by the College of Engineering and Applied Science on page 34. Note that Eco 1 is required, as well as Freshman English.
(2) Approved courses in other engineering departments (CEE, EECS, MSIE, MEM, MSE) and/or in science (chemistry, physics, mathematics, molecular biology or earth and environmental sciences); 6 credit hours total are required; at least 3 credit hours must be in other engineering departments.
(3) Chemistry: 3 credit hours of 200-level or higher.
(4) Chemical Engineering: A total of 3 credit hours is required. At least 1 credit hour must be of engineering design. ChE 185 does not qualify.
(5) Free electives: 6 credit hours in any subject area (including advanced chemical engineering) are required.

Undergraduate Courses
ChE 31. Material and Energy Balances of Chemical Processes (3) fall Material and energy balances with and without chemical reaction. Introduction to phase equilibrium calculations. Applications in chemical process calculations and in design of staged separations: binary distillation, liquid-liquid extraction. Plant trips and special lectures introducing the profession. Prerequisite: Chem 21 or equivalent and Eng 1 previously or concurrently. (ES 2), (ED 1)

ChE 44. Fluid Mechanics (4) spring Fluid mechanics and its applications to chemical processes. Momentum and energy balances in fluid flow. Dimensional analysis. Fluid flow in pipes, packed and fluidized beds. Mixing and agitation. Filtration and sedimentation. (ES 3), (ED 1)

ChE 60. Unit Operations Survey (3) spring The theory of heat, mass and momentum transport. Laminar and turbulent flow of real fluids. Heat transfer by conduction, convection, and radiation. Application to a wide range of operations in the chemical and metallurgical process industries. (ES 2), (ED 1)

ChE 151. Introduction to Heat Transfer (3) fall Fundamental principles of heat transfer. Fourier’s law. Conduction, convection and radiation. Analysis of steady and unsteady state heat transfer. Evaporation and condensation. Applications to the analysis and design of chemical processing units involving heat transfer. Prerequisite: ChE 44. (ES 2), (ED 1)

ChE 179. Professional Development (1) spring Elements of professional growth, registration, ethics, and the responsibilities of engineers both as employees and as independent practitioners. Proprietary information and its handling. Patents and their importance. Discussions with the staff and with visiting lecturers. A few plant trips. (ES 0), (ES 0)

ChE 185. Undergraduate Research I (3) Independent study of a problem involving laboratory investigation, design, or theoretical studies under the guidance of a senior faculty member. (ES 3), (ED 0)

ChE 186. Undergraduate Research II (3) A continuation of the project begun under ChE 185. Prerequisite: ChE 185 or consent of the department chair. (ES 2), (ED 1)

ChE 201. Methods of Analysis in Chemical Engineering (3) fall Analytical and numerical methods of solution applied to dynamic, discrete and continuous chemical engineering processes. Laplace Transforms. Methods of analysis applied to equilibrium, characteristic value and non-linear chemical engineering problems. Prerequisite: Math 205 previously or concurrently and ChE 44. (ES 2), (ED 0)

ChE 202. Chemical Engineering Laboratory I (2) fall The laboratory study of chemical engineering unit operations and the reporting of technical results. One three-hour laboratory and one lecture period per week. Independent study and both group and individual reporting. Prerequisite: ChE 151. (ES 1), (ED 1)

ChE 203. Chemical Engineering Laboratory II (2) spring Laboratory experience with more complex chemical processing situations including processes involving chemical reactions and those controlled automatically. Prerequisite: ChE 244 and ChE 210. (ES 1), (ED 1)

ChE 207. (Math 207) Introduction to Biomedical Engineering and Mathematical Physiology (3) fall Topics in human physiology and mathematical analysis of physiological phenomena, including the cardiovascular and respiratory systems, biomechanics, and renal physiology; broad survey of bioengineering. Independent study projects. Prerequisites: Math 205. (ES 2), (ED 1)

ChE 210. Chemical Engineering Thermodynamics (4) spring Energy relations and their application to chemical engineering. Consideration of flow and nonflow processes. Evaluation of the effects of temperature and pressure on the thermodynamic properties of fluids. Heat effects accompanying phase changes and chemical reactions. Determination of chemical and physical equilibrium. Prerequisite: ChE 31. (ES 3), (ED 1)

ChE 211. Chemical Reactor Design (3) spring The application of chemical kinetics to the design and operation of chemical reactors. Plug flow and continuous stirred tank reactors. Homogeneous and heterogeneous reaction kinetics. Design of isothermal and adiabatic reactors. Prerequisite: ChE 151, ChE 210 or equivalent. (ES 1), (ED 2)

ChE 233. Process Design I (3) fall Design of chemical plants incorporating traditional elements of engineering economics and synthesis of steady-state flowsheets with (1) both heuristic and rigorous optimization methods and (2) consideration of dynamic controllability of the process. Economic principles involved in the selection of process alternatives and determination of process capital, operating costs, and venture profitability. Energy conservation, pinch techniques, heat-exchanger networks, and separation sequences. Considerations of market limitations, environmental and regulatory restrictions, and process safety. Use of modern computer-aided software for steady-state and dynamic simulation and optimization. Group design projects. Prerequisites: ChE 211, ChE 242 and ChE 244. (ES 0), (ED 3)

ChE 234. Process Design II (3) spring Continuation of ChE 233. Prerequisite ChE 233. (ES 0), (ED 3)

ChE 242. Introduction to Process Control and Simulation (3) spring Dynamic simulation of chemical processes. Transfer functions and block diagrams. Introduction to process control equipment. Open-loop and closed-loop stability analysis using root locus and Nyquist techniques. Design of control systems. Prerequisites: ChE 201, ChE 151, and Engr 1. (ES 1), (ED 2)
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ChE 244. Mass Transfer and Separation Processes (3) spring
Difussion, fluxes, and component conservation equations. Fick's law. Unsteady state diffusion. Convective mass transfer. Interphase mass transfer coefficients. Design of multicomponent distillation, absorption, extraction, and fixed-bed processes. Prerequisites: ChE 31 and ChE 44. (ES 1), (ED 2)

ChE 281. Chemical Engineering for Non-Chemical Engineers I (4) fall
Fundamentals of material balances, fluid mechanics and heat transfer. Prerequisites: Undergraduate degree in a scientific or engineering discipline or one semester undergraduate level general chemistry, one semester undergraduate level physics (statics and dynamics), and two semesters undergraduate calculus and department permission.

ChE 282. Chemical Engineering for Non-Chemical Engineers II (4) spring
Fundamentals of heat and mass transfer, process energy balances and unit operations. Prerequisites: ChE 281, or equivalent, and department permission.

For Advanced Undergraduates and Graduate Students

ChE 301. Process Design (3)
Study of the strategy of chemical process design with emphasis on optimum order of steps, flow diagrams, energy balances, recycle ratios and their effect on the economics of the operation. Survey of methods for ordering equations. Discussion of process optimization for non-linear systems. Effects of uncertainty in process design. (ES 0), (ED 3)

ChE 312. (Chm 312, Mat 312) Fundamentals of Corrosion (3)
Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization, and passivity. Non-electrochemical corrosion including mechanisms, theories, and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings, alloys, inhibitors, and passivators. Prerequisite: Mat 205, Chm 187, or equivalent. (ES 3), (ED 0)

ChE 320. Waste Water Control (3)
The physical processes of importance in the design of industrial waste-water treatment facilities. Topics will include sedimentation and filtration processes as well as advanced methods such as adsorption, ion exchange, osmosis, foam, freezing, and hydrate formation. Prerequisite: ChE 211. (ES 2), (ED 1)

ChE 321. Fundamentals of Air Pollution (3)
Introduction to the problems of air pollution including such topics as: sources and dispersion of pollutants; sampling and analysis; technology of economics and control processes; legislation and standards. Prerequisite: senior standing in the College of Engineering and Applied Science. (ES 1), (ED 2)

ChE 331. Separation Processes (3) fall, every other year
Industrial separation chemistry and processes. Computer solutions for simple and complex multicomponent distillation columns. Azeotropic and extractive distillation. Adsorption, ion exchange, and chromatography in packed beds, moving beds and cyclic operation. Synthesis of polymer membrane and its applications to industrial separation processes. (ES 1), (ED 2)

ChE 334. (Mat 334, EES 338) Electron Microscopy and Microanalysis (4) fall
Fundamentals and experimental methods in electron optical techniques including scanning electron microscopy (SEM) conventional transmission (TEM) and scanning transmission (STEM) electron microscopy. Specific topics will include electron optics, electron beam interactions with solids, electron diffraction and chemical microanalysis. Applications to the study of the structure of materials are given. Prerequisite: consent of the department chair. (ES 4), (ED 0)

ChE 335. (Mat 335) Principles of Semiconductor Materials Processing (3)
Description and analysis of the processing steps involved in microelectronic material fabrication. Emphasis will be placed on the chemistry of the fabrication steps, mathematical modeling of the transport and chemical reaction phenomena, and interpretation of experimental methods and data. Prerequisites: a course in thermodynamics, and senior standing. (ES 3), (ED 0)

ChE 341. Biotechnology I (3) fall
Applications of material and energy balances; heat, mass, and momentum transfer; enzyme and microbial kinetics; and mathematical modeling to the engineering design and scale-up of bio-reactor systems. Prerequisites: Math 22, Phys 11, and Chm 187; or the equivalent of each and the consent of the instructor. (ES 1), (ED 2)

ChE 342. Biotechnology II (3) spring
Engineering design and analysis of the unit operations used in the recovery and purification of products manufactured by the biotechnology industries. Requirements for product finishing and waste handling will be addressed. Prerequisite: ChE 341 or equivalent. (ES 1.5), (ED 1.5)

ChE 350. Special Topics (1-3)
A study of areas in chemical engineering not covered in courses presently listed in the catalog. May be repeated for credit if different material is presented.

ChE 360. (ME 360) Nuclear Reactor Engineering (3)
A consideration of the engineering problems related to nuclear reactor design and operation. Topics include fundamental properties of atomic and nuclear radiation, reactor fuels and materials, reactor design and operation, thermal aspects, safety and shielding, instrumentation and control. Course includes several design projects stressing the major topics in the course. Prerequisite: Senior standing in engineering or physical science. (ES 2), (ED 1)

ChE 367. (MAT 367) Metal Films and Coatings Processing, Structure, and Properties (3)
Focus will be on the processing, structure, and properties of metal films and coatings. Processing methods will include evaporation, sputtering, chemical vapor deposition (CVD), plasma-assisted CVD, ion implantation, electrodeposition, metal bath solidification, weld overlay, thermal spraying and diffusion. Characterization of thin films and coatings will be done with the use of sophisticated analytical instrumentation, including spectroscopic methods, microscopy and diffraction techniques. Characterization methods are explored in conjunction with processing techniques and film/coating properties via class assignments that are designed to introduce students to the archival scientific literature. Prerequisite: Senior standing in chemical engineering or materials science and engineering, or permission of the instructor(s). (ES 1.5), (ED 1.5)

ChE 370. Process Safety and Hazard Analysis (3)
A study of the methodology now available for analyzing hazard frequency and level in chemical processes. Applications to real process examples using hazard and operability analysis, fault tree and event tree analysis, "what if" analysis, and preliminary hazard analysis. Also includes a survey of the field of industrial safety. (ES 1.5), (ED 1.5)

ChE 380. Design Projects (1-6) fall-spring
Design project work as a member of a team preferably including students from different disciplines. The project attacks a problem which, when possible, involves one of the local communities or
ChE 386. Process Control (3) fall
Open-loop and closed-loop stability analysis using root locus and Nyquist techniques, design of feedback controllers with time and frequency domain specifications. Experimental process identification. Control of multivariable processes. Introduction to sampled-data control theory. Prerequisite: ChE 242 or equivalent. (ES 1), (ED 2)

ChE 387. (ECE 387, ME 387) Digital Control (3) spring
Sampled-data systems: z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Liapunov stability state feedback control (2 lectures and one laboratory per week). Prerequisite: ChE 386 or ECE 212 or ME 343 or consent of instructor. (ES 1.5), (ED 1.5)

ChE 388. (Chem 388, Mat 388) Polymer Synthesis and Characterization Laboratory (3) spring
Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisite: senior level standing in Ch.E., Chm or Mat, or permission of the instructor. (ES 2), (ED 1)

ChE 389. (ECE 389, ME 389) Control Systems Lab (2) spring
Experiments on a variety of mechanical, electrical and chemical dynamic control systems. Exposure to state-of-the-art control instrumentation: sensors, transmitters, control valves, analog and digital controllers. Emphasis on comparison of theoretical computer simulation predictions with actual experimental data. Lab teams will be interdisciplinary. Prerequisite: ChE 386, ECE 212, or ME 343. (ES 1), (ED 1)

ChE 391. (Chem 391) Colloid and Surface Chemistry (3)
Physical chemistry of everyday phenomena. Intermolecular forces and electrostatic phenomena at interfaces, boundary tensions and films at interfaces, mass and charge transport in colloidal suspensions, electrostatic and London forces in dispersive systems, gas adsorption and heterogeneous catalysis. Prerequisite: Chm 187 or equivalent. (ES 3), (ED 0)

ChE 392. (Chem 392) Introduction to Polymer Science (3) fall
Introduction to concepts of polymer science. Kinetics and mechanism of polymerization, synthesis and processing of polymers, characterization. Relationship of molecular conformation, structure and morphology to physical and mechanical properties. Prerequisite: Chm 187 or equivalent. (ES 1.5), (ED 1.5)

ChE 393. (Chem 393, Mat 393) Physical Polymer Science (3) fall
Structural and physical properties of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline, and paracrystalline states (including viscoelastic and relaxation behavior) for single- and multi-component systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology, and behavior. Prerequisite: senior level standing in Ch.E., Chem, or Mat, or permission of the instructor. (ES 1.5), (ED 1.5)

ChE 394. (Chem 394) Organic Polymer Science I (3) spring
Organic chemistry of synthetic high polymers. Polymer nomenclature, properties, and applications. Functionality and reactivity of monomers and polymers. Mechanism and kinetics of step-growth and chain-growth polymerization in homogenous and heterogenous media. Brief description of emulsion polymerization, ionic polymerization, and copolymerization. Prerequisites: one year of physical chemistry and one year of organic chemistry. (NS)

Graduate Programs
The department of chemical engineering offers graduate programs leading to the master of science, master of engineering, and doctor of philosophy degrees. The programs are all custom tailored for individual student needs and professional goals. These individual programs are made possible by a diversity of faculty interests that are broadened and reinforced by cooperation between the department and several research centers on the campus.

A free flow of personnel and ideas between the centers and academic departments ensures that the student will have the widest choice of research activities. The student is also exposed to a wide range of ideas and information through courses and seminars to which both faculty and center personnel contribute. In addition, strong relationships with industry are maintained by the department and the research centers, some of which operate industrially-sponsored liaison programs whereby fundamental nonproprietary research is performed in areas of specific interest to participating sponsors.

While the department has interacted with most of the centers on campus, it has had unusually strong and continuing liaisons with Emulsion Polymers Institute, Process Modeling and Control Research Center, Institute for Thermo Fluid Engineering and Science, Materials Research Center, Polymer Interfaces Center, and Zettlemoyer Center for Surface Studies.

In addition to interacting with the centers, the department originates and encourages programs that range from those that are classical chemical engineering to those that are distinctly interdisciplinary. The department offers active and growing programs in adhesion and tribology, emulsion polymerization, and latex technology; bulk polymer systems; process control; environmental engineering; thermodynamics; kinetics and catalysis; enzyme technology; and biochemical engineering.

Career Opportunities
Master of science, master of engineering, and doctor of philosophy graduates in the chemical engineering area are sought by industry for activities in the more technical aspects of their operations, especially design, process and product development, and research. Many of these graduates also find opportunities in research or project work in government agencies and in university teaching and research.

Physical Facilities
The department is well equipped for research in colloids and surface science, adhesion and tribology, polymer science and engineering, catalysis and reaction kinetics, thermodynamic property studies, fluid dynamics, heat and mass transfer, process dynamics and control, and enzyme engineering and biochemical engineering.

The departmental and university computing facilities include Pentium-based PCs and SGI workstations, connected by a university-wide high speed network, which in turn provides worldwide networking via the Internet / WWW. The central computer for this network is a 16-processor SGI server that is available for computer-intensive applications. All of these facilities can access a wide variety of general-purpose, and scientific and engineering software via the university and local networks, including software specifically for the steady state and dynamic simulation of chemical engineering systems. The networks are extended as needed to ensure the chemical engineering department has access to the latest computing technology.
Special Programs

Master of engineering design option. For those interested in design, the department offers the master of engineering design option. In this program, the student works on a design project proposed by the process design group of a cooperating industry. Direction of the design project is shared by the cooperating industry and a member of the faculty. Students desiring to enroll in this program should indicate such at the time they apply for admission. Six hours of graduate credit are earned for the design project and the final report.

Polymer science and engineering. The polymers activity includes work done in the Department of Chemical Engineering as well as the departments of chemistry, materials science and physics, the Materials Research Center, the Center for Surface and Coatings Research, the Center for Polymer Science and Engineering, the Emulsion Polymers Institute, and the Polymers Interface Center. More than 20 faculty members from these organizations or areas have major interests in polymers and cooperate on a wide range of research projects. For students with deep interest in the area, degree programs are available leading to the master of science and doctor of philosophy degrees in polymer science and engineering.

Research activities in which chemical engineering students and faculty are involved include studies of the mechanism and kinetics of reactions in emulsion polymerization and copolymerization; colloidal surface and interfacial aspects of emulsion polymers; the processes involved in their preparation, with special attention to the relationship between process parameters and properties of polymers; work on polymer blends, especially interpenetrating polymer networks, and the application of these materials to sound-deadening; rheology of viscoelastic materials; crystallization behavior from polymer melts and solutions; polymer film characteristics and the tailoring of these properties for selective transfer rates; latex film drying rates; polymer interdiffusion studies; characteristics of polymer surfaces and interfaces; and the preparation of polymeric materials from agricultural raw materials.

Major Requirements

All candidates for the master of science degree are required to complete a research report or thesis for which six hours of graduate credit are earned. Course selection is done individually for each student, although ChE 400, ChE 410, ChE 415 and ChE 461 are required courses. Candidates for the master of engineering degree do not do research; all 30 credit hours are fulfilled with course work.

Course selection is done individually for each student, although ChE 400, ChE 410, ChE 415 and ChE 461 are required courses.

In addition to an approved course and thesis program, the Ph.D. student must pass a qualification examination given during the second year of residence.

Advanced Courses in Chemical Engineering

ChE 400. Chemical Engineering Thermodynamics (3) fall
Applications of thermodynamics in chemical engineering. Topics include energy and entropy, heat effects accompanying solution, flow of compressible fluids, refrigeration including solution cycles, vaporization and condensation processes, and chemical equilibria. Prerequisite: an introductory course in thermodynamics. Stein, Santore

ChE 401. Chemical Engineering Thermodynamics II (3) spring, every other year
A detailed study of the uses of thermodynamics in predicting phase equilibria in solid, liquid, and gaseous systems. Fugacities of gas mixtures, liquid mixtures, and solids. Solution theories; uses of equations of state; high-pressure equilibria. Stein

ChE 410. Chemical Reaction Engineering (3) spring
The application of chemical kinetics to the engineering design and operation of reactors. Non-isothermal and adiabatic reactions. Homogeneous and heterogeneous catalysis. Residence time distribution in reactors. Prerequisite: ChE 211. Caram

ChE 413. Heterogeneous Catalysis and Surface Characterization (3) fall, every other year
History and concepts of heterogeneous catalysis. Surface characterization techniques, and atomic structure of surfaces and adsorbed monolayers. Kinetics of elementary steps (adsorption, desorption, and surface reaction) and overall reactions. Catalysis by metals, metal oxides, and sulfides. Industrial applications of catalysis: selective oxidation, pollution control, ammonia synthesis, hydrogenation of carbon monoxide to synthetic fuels and chemicals, polymerization, hydrocracking, and cracking. Wachs

ChE 415. Transport Processes (4) spring
A combined study of the fundamentals of momentum transport, energy transport and mass transport and the analogies between them. Evaluation of transport coefficients for single and multicomponent systems. Analysis of transport phenomena through the equations of continuity, motion, and energy. Prerequisite: ChE 461 or equivalent. Silebi, Caram

ChE 419. (Mech 419) Asymptotic Methods in the Engineering Sciences (3)

ChE 421. Heat Transfer (3)

ChE 427. (ME 427) Multiphase Flow and Heat Transfer (3)
Heat transfer and fluid dynamics of multiphase systems. Subcooled, nucleate, and film boiling; bubble nucleation; dynamics of bubble growth and collapse; vapor-liquid cocurrent flow regimes; two-phase pressure drop and momentum exchange, low instabilities; convective-flow boiling; simultaneous heat and mass transfer. Prerequisite: ChE 421 or ME 321, or courses in the area of transport phenomena. Chen

ChE 428. Rheology (3)
An intensive study of momentum transfer in elastic viscous liquids. Rheological behavior of solution and bulk phase polymers with emphasis on the effect of molecular weight, molecular weight distribution and branching. Derivation of constitutive equations based on both molecular theories and continuum mechanics principles. Application of the momentum equation and selected constitutive equations to geometries associated with viscometric flows. Silebi

ChE 430. Mass Transfer (3) fall, every other year
Theory and developments of the basic diffusion and mass transfer equations and transfer coefficients including simultaneous heat and mass transfer, chemical reaction and dispersion effects. Applications to various industrially important operations including continuous contact mass transfer, absorption, humidification, etc. Brief coverage of equilibrium stage operations as applied to absorption and to binary and multicomponent distillation. Caram, Silebi
ChE 433. (ECE 433, ME 433) State Space Control (3) fall
State-space methods of feedback control system design and
design optimization for invariant and time-varying determinis- tic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin’s Maximum Principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal open-loop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: ME 343 or ECE 212 or ChE 386 or consent of instructor. Johnson, Georgakis

ChE 434. (ECE 434, ME 434) Multivariable Process Control (3)
A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feed forward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: Ch.E. 433 or ME 433 or ECE 433 or consent of instructor. Georgakis

ChE 436. (ECE 436, ME 436) Systems Identification (3)
The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasilinearization and invariant-imbedding techniques for nonlinear system parameter identification included. Prerequisite: Ch.E. 433 or ME 433 or ECE 433 or consent of instructor. Johnson, Georgakis

ChE 437. (ECE 437, ME 437) Stochastic Control (3)
Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gaussian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: Ch.E. 433 or ME 433 or ECE 433 or consent of instructor.

ChE 438. Process Modeling and Control Seminar (1) fall-spring
Presentations and discussions on current methods, approaches, and applications. Credit cannot be used for the M.S. degree.

ChE 444. Bioseparations (3)
Separation techniques for biomolecule isolation and purification. Theory and problems of bioaffinity chromatography, electromigration processes, and aqueous two-phase polymer extraction systems. Engineering principles for scaling-up bioseparation processes. Prerequisite: Consent of the instructor.

ChE 445. Enzyme Engineering (3)
Enzyme characteristics including nomenclature, physical properties, kinetics, and assay methods with emphasis on practical application at commercial scale. Methods of enzyme production and purification. Design and analysis of industrial-scale reactors employing soluble and immobilized enzymes. Prerequisite: Consent of the instructor.

ChE 446. Biochemical Engineering Laboratory (3)
Laboratory and pilot-scale experiments in fermentation and enzyme technology, tissue culture, and separations techniques. Prerequisites: ChE 341 and ChE 444 or ChE 342 previously or concurrently.

ChE 448. Topics in Biochemical Engineering (3) fall
Analysis, discussion, and review of current literature for a topical area of biotechnology. Course may be repeated for credit with the consent of the instructor. Prerequisite: Consent of the instructor.

ChE 450. Special Topics (1-12) fall-spring
An intensive study of some field of chemical engineering not covered in the more general courses. Credit above three hours is granted only when different material is covered.

ChE 451. Problems in Research (1)
Study and discussion of optimal planning of experiments and analysis of experimental data. Discussion of more common and more difficult techniques in the execution of chemical engineering research.

ChE 455. Seminar (1-3) fall-spring
Critical discussion of recent advances in chemical engineering. Credit above one hour is granted only when different material is covered.

ChE 460. Chemical Engineering Project (1-6) fall-spring
An intensive study of one or more areas of chemical engineering, with emphasis on engineering design and applications. A written report is required. May be repeated for credit.

ChE 461. Mathematical Methods in Chemical Engineering (3) fall
Survey of the principal numerical algorithms for: (1) functional approximation, (2) linear and nonlinear algebraic equations, (3) initial and boundary-value ordinary differential equations and (4) elliptic, hyperbolic and parabolic partial differential equations. Analysis of the computational characteristics of numerical algorithms, including algorithm structure, accuracy, convergence, stability and the effect of computer characteristics, e.g., the machine epsilon and dynamic range. Applications of mathematical software in science and engineering. Schiesser

ChE 464. Numerical Methods in Engineering (3) fall
Solution of chemical engineering problems with emphasis on chemical reactions and transport phenomena. Specific topics include Linear Vector Spaces; Eigenvalues, Eigenvectors and Eigenfunctions; First and Higher Order Linear Differential Equations; Bessel and Legendre Functions; Green’s Functions, Sturm-Louisville Problems, Qualitative and Quantitative Methods for Nonlinear Ordinary Differential Equations, Phase Plane; Separation of Variables; Fourier Transform Methods; Method of Characteristics. Example problems from the chemical engineering literature. Georgakis

ChE 467. (CE 473) Environmental Separation and Control (3) fall-spring
Theory and application of adsorption, ion exchange, reverse osmosis, air stripping and chemical oxidation in water and wastewater treatment. Modeling engineered treatment processes. Prerequisite: CE 470 or consent of the instructor.

ChE 480. Research (3) fall-spring
Investigation of a problem in chemical engineering.

ChE 481. Research (3) fall-spring
Continuation of ChE 480.

ChE 482. (Chm 482, Mat 482) Engineering Behavior of Polymers (3) fall-spring
A treatment of the mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizers, moisture and aging on mechanical behavior.
ChE 483. (Chm 483) Emulsion Polymers (3) fall
Examination of fundamental concepts important in the manufacture, characterization, and application of polymer latexes. Topics to be covered will include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation and various application problems. El-Aasser
ChE 484. (Chm 484) Crystalline Polymers (3)
Morphology and behavior of both polymer single crystals and bulk crystallized systems. Relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. Thermodynamics and kinetics of transition phenomena and a brief treatment of hydrodynamic properties and their relationship to crystallization and processing properties. Prerequisite: ChE 392 or ChE 393 or equivalent.
ChE 485. (Chm 485, MAT 485) Polymer Blends and Composites (3) spring, every other year
Synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers are emphasized. Prerequisite: any introductory course in polymers. Sperling
ChE 486. Polymer Processing (3)
Application of fundamental principles of mechanics, fluid dynamics and heat transfer to the analysis of a wide variety of polymer flow processes. A brief survey of the rheological behavior of polymers is also included. Topics include pressurization, pumping, die forming, calendering, coating, molding, fiber spinning and elastic phenomena. Prerequisite: ChE 392 or equivalent. Silebi
ChE 487. Polymer Interfaces (3) spring, every other year
An intensive study of polymer surfaces and interfaces, with special emphasis on thermodynamics, kinetics, and techniques for characterization. Chemistry and physics of adsorbed polymer chains. Diffusion and adhesion at polymer-polymer interfaces, especially as related to mechanical properties such as fracture and toughness will be described. Prerequisite: Introductory polymer course.
ChE 492. (Chm 492) Topics in Polymer Science (3)
Intensive study of topic selected from areas of current research interest such as morphology and mechanical behavior, thermodynamics and kinetics of crystallization, new analytical techniques, molecular weight distribution, non-Newtonian flow behavior, second-order transition phenomena, novel polymer structures. Credit above three hours is granted only when different material is covered. Prerequisite: Chem 392 or equivalent.

Chemistry

Professors. Keith J. Schray, Ph.D. (Penn State), chair; Jack A. Alhadeff, Ph.D. (Oregon Medical School); Ned D. Heindel, Ph.D. (Delaware), Howard S. Bumm Professor of Chemistry; Kamiel Klier, Ph.D. (Czechoslovak Academy of Science, Prague), university professor; Charles S. Kratohvil, Ph.D. (Wisconsin-Madison); John W. Larsen, Ph.D. (Purdue); Steven L. Regen, Ph.D. (M.I.T.); Gary W. Simmons, Ph.D. (Virginia); Daniel Zeroka, Ph.D. (Pennsylvania).
Associate professors. Gregory S. Ferguson, Ph.D. (Cornell); Natalie Foster, Ph.D. (Lehigh); James E. Roberts, Ph.D. (Northwestern), associate chair.
Assistant professors. Li Jia, Ph.D. (Northwestern); Marie C. Messer, Ph.D. (California-San Diego).
Adjunct professors. Andrew K. Godwin, Ph.D. (Pennsylvania); Thomas C. Hamilton, Ph.D. (Wales); Gary D. Kruh, M.D./Ph.D. (Baylor); Tibor Sipos, Ph.D. (Lehigh).
Active emeriti. Fortunato J. Micale, Ph.D. (Lehigh); James E. Sturm, Ph.D. (Notre Dame).

Chemistry is a versatile subject area and the pursuit of a career in chemistry can be a most intellectually satisfying experience. No other basic science touches and shapes as many aspects of modern society as does chemistry. The study of chemistry has provided solutions to complex problems and has improved the quality of all phases of human life from soft contact lenses and synthetic blood to long-lasting paint and alternative fuels. A particular strength of this department is in surface and interface chemistry, which bridges many areas of modern science and technology.

Chemists at all levels of education find a market for their skills and knowledge in many employment areas. Chemists provide the technical backbone for the manufacturing industries (pharmaceuticals, plastics, paper, semiconductor electronics technology, and agriculture), for service industries (clinical and forensic laboratories, academic, environmental protection, and information science) and for governmental positions in regulatory agencies and in science policy analyses. Many chemists are employed in nontraditional areas, such as patent law, insurance underwriting, sales, product management, journalism, and even banking.

The alluring challenge of chemistry inspires many bachelor degree recipients to study for advanced degrees within the discipline of chemistry and in other areas, as well. Chemistry or biochemistry is the strongest preparation for graduate studies or for professional school in the health-related disciplines (medicine, pharmacology, and biochemistry), and for other science programs (materials science, polymers, biotechnology, environmental studies, and mineralogy).

The study of chemistry opens doors to satisfying careers, to a stimulating view of the world, and to a professional life in which one's natural tendency to ask "Why?" can lead to personally rewarding endeavors. The undergraduate curriculum in chemistry contains many of the prerequisites for biology, earth and environmental sciences, materials science, molecular biology, physics, and chemical engineering, allowing students to transfer the majority of credits through the sophomore year.

Chemistry students have the opportunity to design their undergraduate curricula for specialization in a variety of fields:

- **health-related chemistry** (including premedical students)

- **chemistry of materials** (polymers, solid state, surfaces)
  - suggested physics electives: 31, 363.
  - suggested chemistry electives: 312, 388, 391, 392, 393, 394, 396.

- **environmental chemistry**
  - suggested earth and environmental sciences 31, 351
  - suggested chemistry electives: 391.
  - suggested civil engineering elective: 374.

- **geochemistry**
  - suggested earth and environmental sciences electives: 21, 131.
  - suggested chemistry electives: 337, 396.

- **chemistry management**
  - suggested accounting electives: 151, 152, 324.
  - suggested law elective: 201.
  - suggested management electives: 269, 270, 302, 321 or 333.
  - suggested marketing electives: 111, 312.
  - suggested finance electives: 125, 330.
Some of the above courses can be used to waive required graduate courses for the M.B.A. at Lehigh.

B.S. and B.A. Degrees in Chemistry
The Department of Chemistry offers B.S. chemistry programs in both the College of Arts and Sciences and the College of Engineering and Applied Science. In addition, the department offers a B.A. chemistry program in the College of Arts and Sciences. The B.S. chemistry programs in the two colleges are identical in their chemistry and collateral science requirements and are pre-professional in nature. Students planning to attend graduate school in chemistry or an allied science should elect the B.S. program in whichever college to which they have been admitted. The B.A. program in the College of Arts and Sciences is not a pre-professional program and may be elected by students who do not plan to do graduate work in chemistry or allied science but wish a stronger background in chemistry than is provided in the chemistry minor program. The B.A. program also affords a useful tie-in with health-related chemistry, environmental chemistry, geochemistry or chemistry management options (see above). Students may transfer from the B.S. to B.A. programs or vice-versa as late as the junior year, since basic requirements are the same for the two. Students who are in the B.A. program and make a late decision to attend graduate school in chemistry or allied science will have minimal chemistry preparation for this by electing Chemistry 307, Advanced Inorganic Chemistry.

Department Modern Language and Literature Requirement.
The modern foreign language requirement is met by one of three options: 1. Completion of the second semester of a modern foreign language; 2. Certification of language equivalent to this level taken in high school; 3. Substitution of six credits of science electives. If science electives are chosen, non-science distribution requirement must still be met.

B.S. Degree in Chemistry, College of Arts & Sciences

Summary of Requirements

I. College and University (26 credits)
   a. Arts I
      1 credit
   b. English I, 2
      6 credits
   c. College Seminar
      3 credits
   d. College distribution
      16 credits

II. Collateral Sciences (28-29 credits)
   a. Physics 11, 12, 21, 22
      10 credits
   b. Math 21, 22, 23, 205
      15 credits
   c. Engr I or CSc 11
      3-4 credits

III. Chemistry Courses (44 credits)
   a. Introductory Chemistry
      Chm 75, 76
      8 credits
      [Chm 21, 22, 31 sequence may be substituted.]
   b. Organic Chemistry
      Chm 51, 52, 53, 58, 353
      10 credits
   c. Inorganic Chemistry
      Chm 205, 307
      5 credits
   d. Physical Chemistry
      Chm 187, 192, 341
      9 credits
   e. Analytical Chemistry
      Chm 332, 338, 339
      7 credits
   f. Technical Writing
      Chm 201 (W-1 course)
      2 credits
   g. Advanced Chemistry Elective
      [See list of choices which appears below.]
      3 credits

[See list of choices which appears below.]

IV. Free Electives (23 credits)
   Total Credits (121 credits)

Model Roster

freshman year, first semester (15 credits)
   Arts I Choices and Decisions (1)
   Engl I Composition and Literature (3)

   Chm 75 Concepts, Models, and Experiments I (4)
   Math 21 Calculus I (4)
   College Seminar (3)

freshman year, second semester (16 credits)
   Engl 2 Composition and Literature (3)
   Phy 11, 12 Introductory Physics I and Laboratory (5)
   Math 22 Calculus II (4)
   Chm 76 Concepts, Models, and Experiments II (4)

sophomore year, first semester (16-17 credits)
   Chm 51 Organic Chemistry I (3)
   Chm 53 Organic Lab I (1)
   Phy 21 Introductory Phys. II (4)
   Phy 22 Introductory Phys. II Lab (1)
   Math 23 Calculus III (4)
   Engr I or CSc 11 Computer Programming (3-4)

sophomore year, second semester (16 credits)
   Chm 52 Organic Chemistry II (3)
   Chm 58 Organic Chemistry Lab II (1)
   Chm 187 Physical Chemistry I (3)
   Math 205 Linear Methods (3)

junior year, first semester (15 credits)
   Chm 192 Physical Chemistry Lab (2)
   Chm 332 Analytical Chemistry (3)
   Chm 341 Chem. Physics and Bonding (4)
   Chm 205 Main Group Elements (2)

junior year, second semester (15-16 credits)
   Chm 201 Technical Writing (2) or
   approved writing intensive course (3)
   Chm 307 Advanced Inorganic Chem. (3)
   Chm 338 Instrumental Analysis Lab (2)
   Chm 339 Instrumental Analysis (2)
   Chm 353 Organic Analysis Laboratory (2)

senior year, first semester (14 credits)
   advanced chemistry elective (3)*
   distribution requirements — free elective (6)

senior year, second semester (14 credits)
   advanced chemistry elective (3)*,**
   distribution requirements — free electives (11)

* See list of choices which appears below.
**This becomes a free elective if the advanced chemistry elective was taken in the fall semester of the senior year.

Advanced Chemistry Elective Requirement

One 3-credit course selected from the following:
   Chm 358 Advanced Organic Chemistry
   Chm 371 Elements of Biochemistry I
   Chm 376 Advanced Chemistry Research Lab
   Chm 381 Radiation and Structure
   Chm 382 Spectroscopy and Photochemical Kinetics
   Chm 391 Colloid and Surface Chemistry
   Chm 392 Introduction to Polymer Science
   Chm 393 Physical Polymer Science
   Chm 394 Organic Polymer Science
   Phy 363 Physics of Solids

Students are encouraged to take any second course that sequences the first by means of a free elective.
B.A. Degree in Chemistry, College of Arts and Sciences

Summary of Requirements

I. College and University
   a. Arts I
   b. English 1, 2
   c. College Seminar
   d. College distribution
   e. Introductory Chemistry
   f. Chemistry Courses
      Chm 75, 76
      Chm 21, 22, 31 sequence may be substituted.
   g. Technical Writing
      Chm 201 (W-I course)

IV. Free Electives

Total Credits (121 credits)

Model Roster

freshman year (30 credits)

Arts 1
   Choices and Decisions (1)
   College Seminar (3)
   Chm 75
   Concepts, Models, and Experiments I (4)
   Chm 76
   Concepts, Models, and Experiments II (4)
   Engl 1
   Composition and Literature (3)
   Engl 2
   Composition and Literature (3)
   Math 51
   Survey of Calculus I (4)
   Math 52
   Survey of Calculus II (3)
   Phy 11
   Introductory Phys. I (4)
   Phy 12
   Introductory Phys. Lab I (1)

sophomore year (30 credits)

Chm 51
   Organic Chemistry I (3)
Chm 52
   Organic Chemistry II (3)
Chm 53
   Organic Chemistry Lab I (1)
Chm 58
   Organic Chemistry Lab II (1)
Phy 12
   General Phys. (3)
Phy 14
   General Phys. Lab (1)
Math 205
   Linear Methods (3)
Engr 1 or CSc 11
   Computer Programming (3) or distribution requirements — free electives (12)

junior year (30 credits)

Chm 187
   Physical Chemistry I (3) or
Chm 194
   Phys. Chem. for Biol. Sci. (3)
Chm 192
   Physical Chemistry Lab (2)
Chm 201
   Technical Writing (2) (W-I course) or approved writing-intensive course (3)
Chm 205
   Main Group Elements (2) or approved writing-intensive course (3)
Chm 307
   Advanced Inorganic Chemistry (3)
Chm 332
   Analytical Chemistry (3)

senior year (31 credits)

Chem. / Chem. related courses (7) *
   distribution requirements — free electives (24)

   * At least one course out of the seven credits required in this category must be a chemistry laboratory numbered 300 or higher. As many as two credits of research (Chm 375) may be used toward meeting the total of seven credits. Courses in this category can be selected from the following suggested tracks but the student in the B.A. degree program need not follow any of these tracks...the suggested tracks are meant for guidance only:
   Environmental/Analytical: Chm 338, 339, 353
   Materials/Physical/Inorganic: Chm 307, 312, 341, 391, 395
   Polymer: Chm 388, 392, 393, 394

B.S. Degree in Chemistry, College of Engr. & Applied Science

Summary of Requirements

I. College distribution
   24 credits

II. Physics, math, and computing
   28 credits

III. Chemistry
   44 credits

IV. Unrestricted electives
   27 credits

Total credits 123 credits

Model Roster

freshman year (30-31 credits)

A student should follow the normal freshman year in the College of Engineering and Applied Science and observe the following note.

Note: It is recommended that, where possible, students planning to major in chemistry take Chemistry 75 in the fall semester and Chemistry 76 in the spring semester of the freshman year. For such students the elective in the spring semester is displaced to a subsequent semester. The Chemistry 21/22/31 sequence may be substituted.

sophomore year, first semester (17 credits)

Chm 51
   Organic Chemistry I (3)
Chm 53
   Organic Chemistry Laboratory I (1)
Phy 21
   Introductory Physics II (4)
Phy 22
   Introductory Physics Laboratory II (1)
Math 23
   Calculus III (4)
modern foreign language requirement (4)*
(See details above)

*sophomore year, second semester (17 credits)

Chm 52
   Organic Chemistry II (3)
Chm 58
   Organic Chemistry Laboratory II (1)
Chm 187
   Physical Chemistry I (3)
Math 205
   Linear Methods (3)
modern foreign language requirement (4)
(See details above)

humanities/social science requirement (3)

junior year, first semester (15 credits)

Chm 192
   Physical Chemistry Laboratory I (2)
Chm 205
   Main Group Elements (2)
Chm 332
   Analytical Chemistry (3)
Chm 341
   Chemical Physics and Bonding (4)
Eco 1
   Economics (4)

junior year, second semester (17-18 credits)

Chm 201
   Technical Writing (2) or approved writing-intensive course (3)
<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chm 307</td>
<td>Advanced Inorganic Chem. (3)</td>
</tr>
<tr>
<td>Chm 338</td>
<td>Instrumental Analysis Lab (2)</td>
</tr>
<tr>
<td>Chm 339</td>
<td>Instrumental Analysis (2)</td>
</tr>
<tr>
<td>Chm 353</td>
<td>Organic Analysis Laboratory (2)</td>
</tr>
<tr>
<td></td>
<td>Humanities / Social Science requirement (3)</td>
</tr>
<tr>
<td></td>
<td>Elective, Engr I, CSc 11 or</td>
</tr>
</tbody>
</table>

**senior year, first semester (14 credits)**
- Advanced chemistry elective (3)
- Humanities / Social Science requirement (3)
- Elective, Engr I, CSc 11 or
- Modern Foreign Language (3-4)
- Science Seminar (1)

**senior year, second semester (13 credits)**
- Advanced chemistry elective (3)*, **
- free electives (8)

* See list of choices for the advanced chemistry elective requirement under the B.S. degree in chemistry / College of Arts and Sciences.
** This becomes a free elective if the advanced chemistry elective requirement was taken in the fall of the senior year.

### Five-Year Bachelor's/Master's Programs

Five-year programs may be arranged for students to receive B.S. or B.A. degrees and the M.S. degrees in chemistry with a concentration in one of several fields of chemistry (inorganic, organic, analytical, physical, polymers, biochemistry, or materials chemistry). A specific program offered by the Department of Chemistry is the five-year B.S. / M.S. program, which focuses on materials education from a chemistry perspective. Students are awarded B.S. and M.S. degrees in chemistry upon completion of all requirements. Specific features of the program include participation in a weekly seminar during the academic year for credit, and summer internships for credit in university, industrial, government, or national laboratories. Materials-related electives are selected from suggested lists of courses in materials science, polymers, solid-state chemistry and physics. Additional information may be obtained from Professor Kraihanzel or Professor Klier.

### Model Roster

#### freshman year (30-31 credits)

A student should follow the normal B.S. in chemistry freshman year for the college in which the student is enrolled and should observe the following note.

Note: It is recommended that, where possible, students planning to major in chemistry take Chemistry 75 in the fall semester and Chemistry 76 in the spring semester of the freshman year. For such students the elective in the spring semester is displaced to a subsequent semester. The Chemistry 21/22/31 sequence may be substituted.

#### summer I

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Chm 163</td>
<td>Chemistry of Materials I (4)</td>
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</table>

#### sophomore year, first semester (17-18 credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Chm 51</td>
<td>Organic Chemistry I (3)</td>
</tr>
<tr>
<td>Chm 53</td>
<td>Organic Chemistry Laboratory I (1)</td>
</tr>
<tr>
<td>Math 23</td>
<td>Calculus III (4)</td>
</tr>
<tr>
<td>Phy 21</td>
<td>Introductory Physics II (4)</td>
</tr>
<tr>
<td>Phy 22</td>
<td>Introductory Physics Lab II (1)</td>
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<tr>
<td>*</td>
<td>Elective, Engr I, CSc 11 or</td>
</tr>
<tr>
<td></td>
<td>Modern Foreign Language (3-4)</td>
</tr>
<tr>
<td>Chm 363</td>
<td>Science Seminar (1)</td>
</tr>
</tbody>
</table>

#### sophomore year, second semester (17 credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chm 52</td>
<td>Organic Chemistry II (3)</td>
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<tr>
<td>Chm 58</td>
<td>Organic Chemistry Laboratory II (1)</td>
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</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Chm 187</td>
<td>Physical Chemistry I (3)</td>
</tr>
<tr>
<td>Math 205</td>
<td>Linear Methods (3)</td>
</tr>
<tr>
<td>*</td>
<td>Elective, Engr I, CSc 11 or</td>
</tr>
<tr>
<td></td>
<td>Modern Foreign Language (6)</td>
</tr>
<tr>
<td>Chm 363</td>
<td>Science Seminar (1)</td>
</tr>
</tbody>
</table>

### summer II

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chm 263</td>
<td>Chemistry of Materials II (4)</td>
</tr>
</tbody>
</table>

#### junior year, first semester (14 credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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<tbody>
<tr>
<td>Chm 192</td>
<td>Physical Chemistry Laboratory (2)</td>
</tr>
<tr>
<td>Chm 205</td>
<td>Main Group Elements (2)</td>
</tr>
<tr>
<td>Chm 332</td>
<td>Analytical Chemistry (3)</td>
</tr>
<tr>
<td>Chm 341</td>
<td>Chemical Physics and Bonding (4)</td>
</tr>
<tr>
<td>Chm 363</td>
<td>Distribution requirement / elective (3)</td>
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</table>

#### junior year, second semester (15-16 credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chm 201</td>
<td>Technical Writing (2) or</td>
</tr>
<tr>
<td></td>
<td>approved writing-intensive course (3)</td>
</tr>
<tr>
<td>Chm 307</td>
<td>Advanced Inorganic Chemistry (3)</td>
</tr>
<tr>
<td>Chm 338</td>
<td>Instrumental Analysis Laboratory (2)</td>
</tr>
<tr>
<td>Chm 339</td>
<td>Instrumental Analysis (2)</td>
</tr>
<tr>
<td>Chm 363</td>
<td>Science Seminar (1)</td>
</tr>
<tr>
<td>*</td>
<td>Distribution requirements (3)</td>
</tr>
<tr>
<td>**</td>
<td>Program related electives (2)</td>
</tr>
</tbody>
</table>

### summer III

Off-campus experience in an industrial, national or government laboratory.

#### senior year, first semester (16 credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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<tbody>
<tr>
<td>Chm 363</td>
<td>Science Seminar (1)</td>
</tr>
<tr>
<td>*</td>
<td>Advanced Chemistry Elective (3)</td>
</tr>
<tr>
<td><strong>/</strong>*</td>
<td>Distribution requirement (3)</td>
</tr>
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#### senior year, second semester (16 credits)

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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<tbody>
<tr>
<td>Chm 363</td>
<td>Science Seminar (1)</td>
</tr>
<tr>
<td>*</td>
<td>Electives (6)</td>
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<tr>
<td><strong>/</strong>*</td>
<td>Program related electives (9)</td>
</tr>
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</table>

### fifth year leading to MS degree

#### summer IV

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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<tbody>
<tr>
<td>Chm 421</td>
<td>Chemistry Research (3)</td>
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</table>

#### fifth year, fall semester (10 credits)

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>Chm 402</td>
<td>Physical Inorganic Chemistry (3)</td>
</tr>
<tr>
<td>Chm 421</td>
<td>Chemistry Research (3)</td>
</tr>
<tr>
<td>***</td>
<td>Program related electives (4)</td>
</tr>
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</table>

#### fifth year, spring semester (10 credits)

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>Chm 443</td>
<td>Solid State Chemistry (3)</td>
</tr>
<tr>
<td>Chm 481</td>
<td>Graduate Seminar (1)</td>
</tr>
<tr>
<td>***</td>
<td>Program related electives (6)</td>
</tr>
</tbody>
</table>

* Courses which meet college distribution requirements.

** Some appropriate program related electives are:

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phy 362</td>
<td>Atomic and Molecular Physics (3)</td>
</tr>
<tr>
<td>Phy 363</td>
<td>Solid State Physics (3)</td>
</tr>
<tr>
<td>Mat 10</td>
<td>Materials Laboratory (1)</td>
</tr>
<tr>
<td>Mat 33</td>
<td>Engineering Materials and Processes (3)</td>
</tr>
<tr>
<td>Mat 201</td>
<td>Physical Properties of Materials (3)</td>
</tr>
<tr>
<td>Mat 203</td>
<td>Structure Characterization Materials (3)</td>
</tr>
<tr>
<td>Mat 204</td>
<td>Processing / Properties - Polymeric Materials (3)</td>
</tr>
<tr>
<td>Mat 214</td>
<td>Processing / Properties of Ceramic Materials (3)</td>
</tr>
<tr>
<td>Mat 216</td>
<td>Diffusion and Phase Transformations (3)</td>
</tr>
<tr>
<td>Mat 302</td>
<td>Electronic Properties of Materials (3)</td>
</tr>
<tr>
<td>Chm 312/Mat 312</td>
<td>Fundamentals of Corrosion (3)</td>
</tr>
<tr>
<td>Mat 317</td>
<td>Imperfections in Crystals (3)</td>
</tr>
<tr>
<td>Mat 334</td>
<td>Electron Microscopy, Microanalysis (4)</td>
</tr>
</tbody>
</table>
Mat 343 / Chm 393 Physical Polymer Science (3)
Chm 353 Organic Analysis Laboratory (3)
Chm 375 Research Chemistry Laboratory (1-3)
Chm 376 Advanced Research Chemistry Lab (1-6)
Chm 394/ChE 394 Organic Polymer Sciences (3)

***Graduate level course in chemistry, physics or materials science.

B.S. in Biochemistry
Interdepartmental B.S. biochemistry majors are offered in both the College of Arts and Sciences and the College of Engineering and Applied Science. Faculty currently serving as advisors with whom a major can be declared are Linda Lowe-Krentz in biological sciences and Jack Alhadeff in chemistry. Please see the section on biochemistry for details on each major.

Minor in Chemistry
A minor in chemistry may be achieved by completing the following requirements:

Chm 31 Chemical Equilibria in Aqueous Systems (3)
Chm 51 Organic Chemistry I (3)
Chm 53 Organic Chemistry Laboratory I (1)
Chm 187 Physical Chemistry I (3)
Chm 192 Physical Chemistry Laboratory (2)
Chm 332 Analytical Chemistry (3)

Total Credits (15 credits)

Necessary pre- or co-requisites for the above would be Chm 21 and 22, Math 21 and Phy 11.

Students who wish to minor in chemistry but whose major program requires any of the above courses may achieve the minor with substitutions approved by the department chair.

Undergraduate Courses in Chemistry

Chm 5. Chemistry and National Issues (3) spring

Chm 21. Introductory Chemical Principles (4) fall-spring
An introduction to important topics in chemistry. These include atomic structure, bonding in inorganic and organic compounds, states of matter, chemical equilibrium, acid-base theories and electrochemistry. Three lectures, one recitation. (NS)

Chm 22. Chemical Principles Laboratory (1) fall-spring
A laboratory course to be taken concurrently with Chm 21. One three-hour laboratory period per week. (NS)

Chm 31. Chemical Equilibria in Aqueous Systems (3) fall-spring
A study of the theoretical basis and practical applications of equilibria in aqueous solutions, including acid-base, precipitation-solubility, metal-ligand, oxidation-reduction and distribution equilibria. Introduction to chemical thermodynamics, spectrophotometry, potentiometry and chromatography. The laboratory work emphasizes the qualitative and quantitative analysis of equilibria in aqueous media. Prerequisite: Chm 21, Math 21, 31 or 51. Two lectures and one three-hour laboratory period. (NS)

Chm 51. Organic Chemistry I (3) fall
Systematic survey of the typical compounds of carbon, their classification, and general relations; study of synthetic reactions. Prerequisite: Chm 21 or 75. (NS)

Chm 52. Organic Chemistry II (3) spring
Continuation of Chm 51. Prerequisite: Chm 51. (NS)

Chm 53. Organic Chemistry Laboratory I (1) fall
Preparation of pure organic compounds. Modern techniques of characterization. Prerequisite: Chm 51 previously or concurrently. (NS)

Chm 58. Organic Chemistry Laboratory II (1) spring
Continuation of Organic Chemistry Laboratory. I. Prerequisite: Chm 53 previously; Chm 52 previously or concurrently. (NS)

Chm 75. Concepts, Models and Experiments I (4) fall
A first-semester course in chemistry for students planning to major in chemistry, biochemistry, chemical engineering, materials science, or other chemistry-related fields. Chemical and physical properties, structures, bonding concepts, and quantitative analysis. Laboratory includes synthesis, separation and analysis procedures; computer applications to chemistry. Three lectures, one laboratory. (NS)

Chm 76. Concepts, Models and Experiments II (4) spring
Continuation of Chemistry 75. Three lectures, one laboratory. Prerequisite: Chm 75 or departmental consent. (NS)

Chm 163. Chemistry of Materials I (4) summer
Research laboratory for students enrolled in the five-year B.S. / M.S. chemistry of materials program. (NS)

Chm 177. Introduction to Research (1-2) fall-spring
For advanced freshmen and sophomore chemistry majors. May be repeated for credit. Prerequisite: Consent of department chair. (NS)

Chm 187. Physical Chemistry I (3) spring
Development of the principles of thermodynamics and their application to systems in which composition is of major concern: solutions, chemical and phase equilibria. Elements of chemical reaction kinetics. Prerequisite: Chm 31 or 76, and Math 21, 31 or 51 previously or concurrently. (NS)

Chm 189. Physical Chemistry II (3) fall

Chm 192. Physical Chemistry Laboratory (2)
Laboratory studies that illustrate the various fields of study in experimental physical chemistry. Prerequisite: Chm 187. (NS)

Chm 194. Physical Chemistry for Biological Sciences (3) fall
The principles and applications of physical chemical concepts to systems of biological interest, including the gas laws, thermodynamics of metabolic reactions, colligative properties, electrochemical equilibria, reaction kinetics and enzyme catalysis, and transport of macromolecules and viruses. Prerequisite: Chm 21 or 75. (NS)

Chm 201. Technical Writing (2)
Principal types of written communications used by professional chemists including informative abstracts, research proposals, progress reports, executive summaries for nonchemist decision makers and proper written experimental procedures, tables, schemes and figures. Prerequisite: Junior standing in chemistry major or consent of the department chair. (ND)

Chm 205. Main Group Elements (2) fall
Chemistry of the main group elements. Prerequisite: Chm 31 or 76. (NS)
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Description</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chm 209</td>
<td>Chemistry of Organic and Inorganic Materials (3)</td>
<td>fall</td>
<td>A systematic study of the most important organic and inorganic structures, covering synthesis, nomenclature, reactions, and properties. Grouping of elements with similar properties within the periodic table is stressed. The nature of the covalent bond will be emphasized. Crystal structures and physical properties.</td>
<td>Chm 21 or 75. Sperling. (NS)</td>
</tr>
<tr>
<td>Chm 250</td>
<td>Special Topics (1-3)</td>
<td>Selected topics in chemistry. May be repeated for credit when different topics are offered. (NS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chm 263</td>
<td>Chemistry of Materials II (4)</td>
<td>summer</td>
<td>Research laboratory for students enrolled in the five-year B.S./M.S. chemistry of materials program. (NS)</td>
<td></td>
</tr>
<tr>
<td>Chm 307</td>
<td>Advanced Inorganic Chemistry (3)</td>
<td>spring</td>
<td>Introduction to transition metal complexes; theories of bonding; kinetics and mechanisms of transition metal complex reactions; selected aspects of organometallic chemistry; bioinorganic chemistry.</td>
<td>Chm 341. (NS)</td>
</tr>
<tr>
<td>Chm 312</td>
<td>(ChE 312, Mat 312) Fundamentals of Corrosion (3)</td>
<td>fall</td>
<td>Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization and passivity. Non-electrochemical corrosion including mechanisms, theories and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings alloys, inhibitors, and passivators.</td>
<td>Mat 205 or Chm 187. (NS)</td>
</tr>
<tr>
<td>Chm 330</td>
<td>Analytical Chemistry (3)</td>
<td>fall</td>
<td>Theory and practice of chemical analysis. Principles of quantitative separations and determinations; theory and application of selected optical and electrical instruments in analytical chemistry; interpretation of numerical data, design of experiments, solute distribution in separation methods.</td>
<td>Chm 31 and 51. (NS)</td>
</tr>
<tr>
<td>Chm 336</td>
<td>Clinical Chemistry (3)</td>
<td>spring</td>
<td>Discussion of methods in common use and the biochemical-medical significance of the results.</td>
<td>Chm 332 and 52. Schray. (NS)</td>
</tr>
<tr>
<td>Chm 337</td>
<td>(EES 337, Mat 333) X-ray Diffraction of Materials (3)</td>
<td>fall</td>
<td>Introduction to crystal symmetry, point groups, and space groups. Emphasis on materials characterization by X-ray diffraction and electron diffraction. Specific topics include crystallographic notation, stereographic projections, orientation of single crystals, textures, phase identification, quantitative analysis, stress measurement, electron diffraction, ring and spot patterns, convergent beam electron diffraction (CBED), and space group determination. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Lectures and laboratory work.</td>
<td>Mat 203 or EES 131 or senior standing in chemistry. Lyman, Chan. (NS)</td>
</tr>
<tr>
<td>Chm 338</td>
<td>Instrumental Analysis Laboratory (2)</td>
<td>spring</td>
<td>Laboratory studies of modern methods of instrumental analysis emphasizing function and characteristics of instrumentation, data, processing, and experimental design. Prerequisites: Chm 339 previously or concurrently. (NS)</td>
<td></td>
</tr>
<tr>
<td>Chm 339</td>
<td>Instrumental Analysis (2)</td>
<td>spring</td>
<td>Principles and applications of modern methods of analytical analysis including optical spectroscopy, nuclear magnetic resonance spectroscopy, mass spectrometry, electrochemical methods, chromatography, thermal methods, and surface characterization. Prerequisite: Chm 332. (NS)</td>
<td></td>
</tr>
<tr>
<td>Chm 350</td>
<td>Special Topics (1-3)</td>
<td>Selected advanced topics in chemistry. May be repeated for credit when different topics are offered. (NS)</td>
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<td></td>
</tr>
<tr>
<td>Chm 353</td>
<td>Organic Analysis Laboratory (2)</td>
<td>spring</td>
<td>Identification of organic compounds as single components and mixtures. Application of combined chemical and spectral assay techniques. Use and interpretation of data from nuclear magnetic resonance, infrared, and mass spectroscopic examinations. Separation techniques for mixtures. Prerequisites: Chm 52 and 58. (NS)</td>
<td></td>
</tr>
<tr>
<td>Chm 357</td>
<td>Advanced Organic Chemistry (3)</td>
<td>fall</td>
<td>Reaction mechanism types and supporting physical-chemical data. Classes of mechanisms include elimination, substitution, rearrangement, oxidation-reduction, enolate alkylations, and others.</td>
<td>one year of organic chemistry. (NS)</td>
</tr>
<tr>
<td>Chm 363</td>
<td>Science Seminar (1)</td>
<td>fall-spring</td>
<td>Discussion of current research in materials chemistry. For students enrolled in the five-year B.S./M.S. chemistry of materials program. May be repeated for credit. (NS)</td>
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</tr>
<tr>
<td>Chm 366</td>
<td>Advanced Organic Laboratory (2)</td>
<td>The synthesis and study of organic compounds illustrating the important techniques and special pieces of apparatus commonly used in organic chemical research.</td>
<td>one year of organic chemistry and laboratory. (NS)</td>
<td></td>
</tr>
<tr>
<td>Chm 371</td>
<td>(BioS 371) Elements of Biochemistry I (3)</td>
<td>fall</td>
<td>A general study of carbohydrates, proteins, lipids, nucleic acids, and other biological substances and their importance in life processes. Protein and enzyme chemistry are emphasized.</td>
<td>one year of organic chemistry. (NS)</td>
</tr>
<tr>
<td>Chm 372</td>
<td>(BioS 372) Elements of Biochemistry II (3)</td>
<td>spring</td>
<td>Dynamic aspects of biochemistry: enzyme reactions including energetics, kinetics and mechanisms, metabolism of carbohydrates, lipids, proteins and nucleic acids, photosynthesis, electron transport mechanisms, coupled reactions, phosphorylations, and the synthesis of biological macromolecules.</td>
<td>Chm 371. (NS)</td>
</tr>
<tr>
<td>Chm 375</td>
<td>Research Chemistry Laboratory (1-3)</td>
<td>fall-spring</td>
<td>An introduction to independent study or laboratory investigation under faculty guidance. Prerequisite: consent of faculty research supervisor. (NS)</td>
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</tr>
<tr>
<td>Chm 376</td>
<td>Advanced Research Chemistry Laboratory (1-6)</td>
<td>fall-spring</td>
<td>Advanced independent study or laboratory investigation under faculty guidance. Prerequisite: 3 credits of Chm 375. Consent of faculty research supervisor. May be repeated for credit. (NS)</td>
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</tr>
<tr>
<td>Chm 377</td>
<td>(BioS 377) Biochemistry Laboratory (3)</td>
<td>fall</td>
<td>Laboratory studies of the properties of chemicals of biological origin and the influence of chemical and physical factors on these</td>
<td></td>
</tr>
</tbody>
</table>
properties. Laboratory techniques used for the isolation and identification of biochemicals. Prerequisite: Chm 371, previously or concurrently. (NS)

Chm 378. (BioS 378) Biochemical Preparations (1-3) spring A laboratory course involving the preparation or isolation, purification and identification of chemicals of biological origin. Prerequisites: Chm 377 and 372, previously or concurrently. (NS)

Chm 381. Radiation and Structure (3) spring Quantum chemistry and group theory applied to molecular orbital theory of bonding, structure, and spectroscopy. Study of selection rules for chemical and photochemical reactions. Prerequisites: Chm 341 and Math 205. (NS)

Chm 382. Spectroscopy and Photochemical Kinetics (3) spring Applications of electronic, infrared, and microwave spectroscopy to the study of molecular structure. Chemical consequences of intramolecular excitation; quantum efficiencies and reaction mechanisms; pulse excitation and dynamics of elementary processes. Prerequisite: Chm 341. (NS)

Chm 385. Physical Chemistry of Printing Inks (3) fall Physical chemical mechanisms of printing processes; composition, dispersion processes for pigments, rheology and printability of inks; color-matching; development of solventless inks and specialty inks. Prerequisite: Chm 187 or equivalent. (NS)

Chm 388. (ChE 388) Polymer Synthesis and Characterization Laboratory (3) spring Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisites: Chm 187, 189 or 341 and 51. El-Aasser. (NS)

Chm 391. (ChE 391) Colloid and Surface Chemistry (3) fall Physical chemistry of everyday phenomena. Intermolecular forces and electrostatic phenomena at interfaces; boundary tensions and films at interfaces, mass and charge transport in colloidal suspensions, electrostatic and London forces in disperse systems, gas adsorption and heterogeneous catalysis. Prerequisite: Chm 187 or equivalent. Chaudhury. (NS)

Chm 392. (ChE 392) Introduction to Polymer Science (3) spring Introduction to concepts of polymer science. Kinetics and mechanisms of polymerization; synthesis and processing of polymers, characterization. Relationship of molecular conformation, structure and morphology to physical and mechanical properties. Prerequisite: Chm 187 or equivalent. Sperling. (NS)

Chm 393. (ChE 393, Mat 393) Physical Polymer Science (3) fall Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy crystalline and paracrystalline states (including viscoelastic and relaxation behavior) for single- and multi-component systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology and behavior. Prerequisite: one year of physical chemistry. Sperling. (NS)

Chm 394. (ChE 394) Organic Polymer Science I (3) spring Organic chemistry of synthetic high polymers. Polymer nomenclature, properties, and applications. Functionality and reactivity or monomers and polymers. Mechanism and kinetics of step-growth and chain-growth polymerization in homogeneous and heterogeneous media. Brief description of emulsion polymerization, ionic polymerization, and copolymerization. Prerequisites: one year of physical chemistry and one year of organic chemistry. (NS)

Chm 396. (Mat 396) Chemistry of Nonmetallic Solids (3) spring Chemistry of ionic and electronic defects in nonmetallic solids and their influence on chemical and physical properties. Intrinsic and impurity controlled defects nonstoichiometric compounds, defect interactions. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, and photoconductivity. Prerequisite: Chm 187 or Mat 205 or equivalent. (NS)

Graduate Programs in Chemistry

The department of chemistry offers graduate studies leading to several advanced degrees. These include master of science and doctor of philosophy degrees in chemistry, a doctor of arts in chemistry, master of science and doctor of philosophy degrees in physiological chemistry and a master of science in clinical chemistry. Master of science and doctor of philosophy degrees in chemistry may be obtained by study and research in the following areas of chemistry—analytical, biochemical, inorganic, organic, physical and polymers. Additional information concerning the physiological chemistry and clinical chemistry programs may be obtained from Section IV of this catalog. The doctor of arts degree includes broad course work in many of the major subdisciplines of chemistry and requires two areas of specialization. A laboratory problem in chemistry (at the M.S. level) and a chemical education project (at the doctoral level) are required. A teaching internship (Chm 411) and an industrial externship are part of the degree program—a program which is particularly intended to upgrade college teachers presently employed in academia but not holding the doctorate.

The chemistry department also admits students to the master of science and doctor of philosophy degree programs in polymer science and engineering. These are interdisciplinary programs which are described in Section IV of this catalog and are not administered by the chemistry department. The following information on admissions, proficiency examinations and other policies applies to all of the programs listed above but not to the interdisciplinary polymer science and engineering program.

A student who performs well on one or more of these tests has an opportunity to take advanced level and special topics courses at an earlier than normal time and may in fact begin graduate research during the first year. A Ph.D. candidate must show proficiency in three areas and an M.S. candidate in two areas within the first year in residence. A student who fulfills one or more of the proficiency examinations will meet with Professor Roberts, faculty graduate coordinator, to determine an appropriate course of action in light of the exam performance, projected major and degree aspiration. Two optional routes are available for demonstration of proficiency. (1) The student through self-study and auditing of
appropriate courses may prepare for a retaking of a proficiency examination at the beginning of the second semester in residence. (2) Alternatively, the student may enroll in appropriate 300 or 400 level courses during the first year in residence. A grade of B- or better in an appropriate 300-400 level course will be considered equivalent to passing the proficiency examination in that area. Courses taken as a means of demonstrating proficiency will be acceptable on the M.S. or Ph.D. graduate program.

Work for the master's degree requires at least 30 credits—a minimum of 24 course credits and 6 credits of research (which may involve either a laboratory or literature research project). Except for research and one credit of Chm 481 (seminar), there are no required courses for the M.S., once proficiency has been established. The courses taken are those deemed appropriate for the student's area of concentration. There is a one-credit seminar requirement for the M.S. Normally, work for the master's degree can be completed in 1½ calendar years.

Completion of a doctor of philosophy degree program normally requires a minimum of four years full-time work after entrance with a bachelor's degree. There are no specific course credit requirements for the Ph.D.; however, approved degree programs generally have at least 30 hours of course work (including any applied toward a master's degree) and 6 credits of research. Thus, the program consists of approximately one-third formal course work and two-thirds independent study and research. There is a foreign language requirement for the Ph.D. First year college proficiency in one of the four languages—French, German, Russian or Japanese—must be established on some basis. There is also a two-credit seminar requirement. After Ph.D. proficiency has been established and the research advisor selected (this must be done by the end of the first year in residence), the major hurdles are the doctoral examinations (both written and oral) in the student's area of concentration which must be passed by the end of 2½ years of residence. If this hurdle surmounted, the remaining time is spent completing (and ultimately defending) the dissertation research under the guidance of the research advisor and the dissertation committee.

Most of the chemistry facilities are housed in the 90,000-square-foot chemistry complex, first occupied in 1975. The seven-story Seeley G. Mudd Building affords laboratory space of modern design; the top three floors are devoted to research laboratories. Most of the research laboratories in the adjacent Sinclair Laboratory are assigned to chemistry professors who specialize in research in surface and interface chemistry.

Biochemistry research is located in Iacocca Hall of the Mountaintop Campus. Physiological chemistry research is located in the Seeley G. Mudd Building. Solid-state chemical research is located in the Sherman Fairchild Laboratory, in Whitaker Laboratory, in the Seeley G. Mudd Building, and in Sinclair Laboratory. Polymer chemistry research laboratories are located in Whitaker Laboratory, Sinclair Laboratory, Iacocca Hall on the Mountaintop Campus, and the Seeley G. Mudd Building.

Current Research Projects
Current research projects of interest are listed below.

Analytical chemistry. NMR studies of organic solids and polymers; electrochemical reduction and oxidation mechanisms of organic compounds; clinical-biomedical applications, mechanisms of electrode processes, adsorption.

Biochemistry. Characterization of lysosomal glycosidases and glycolal transferases; functional role of carbohydrates in glycoproteins; abnormal glycoprotein metabolism in human diseases; development of in vitro evaluation techniques for prescreening candidate pharmaceuticals; structural dynamics and molecular associations of biologically significant molecules.

Inorganic chemistry. Synthesis, characterization and catalytic chemistry of transition metal organometallic complexes; applications of molecular mechanics and molecular orbital theories in studies of inorganic and organic derivatives of the representative main group elements and transition metals; synthesis of solid catalysts including oxides, sulfides, zeolites and supported metals; use of organometallic and coordination chemistry in the synthesis of thin-film materials, and as a guiding principle in adhesion. Use of organometallic chemistry as a vehicile for various catalytic transformations including polymerization and small molecule synthesis.

Materials and polymer chemistry. Inorganic and organometallic chemistry in the synthesis of thin-film materials; synthesis at and dynamics of polymer interfaces; polymerization catalysis; synthesis, structure, conformation and properties of high polymers; techniques and kinetics of emulsion polymerization and film formation; acoustic, optical, permeability, dielectric and mechanical behavior of thin films, coatings and bulk polymers; molecular structure, relaxation behavior and energetics of fracture; elastic and viscoelastic behavior of interpenetrating and rubbery networks; effects of ordering in the glassy state and crystalization on physical properties; crystallization under the influence of shear gradients; physical chemistry of polymer composites such as polymer-concrete and filled polymers; interfacial characteristics and interactions in polymer-inorganic systems; NMR studies of polymers in aqueous solutions and gels; ionic motion through polymer films.

Organic chemistry. Synthesis of medicinal agents, correlation of molecular structure with pharmacological behavior; chemical models for biochemical reactions; biosynthesis involving indole intermediates; chemistry of monolayers and organized molecule assemblies; coal chemistry.

Physical chemistry. Chemistry at surfaces and interfaces of catalysts, coatings, structural alloys and microelectronics using an array of surface sensitive methods; nonlinear spectroscopy of dynamics of I, s-I, s-g, and polymer interfaces; NMR and XPS imaging, ARXPS and ARUPS, surface diffraction methods including XPD, surface dynamics in nano-, meso- and macroscopic dimensions, STM/APM in UHV and "real" environments, theory including ab initio FLAPW-DFT for periodic systems for interpretation of XPS, UPS, optical, QNM, FTIR and Raman spectra, as well as transition states both in thermal and photochemical reactions; NMR studies of polymer adsorption and polymer miscibility; the macromolecular structure of kerogens; mineral matter catalyzed reactions in petroleum formation; carbon catalyzed reactions; applications of electronic structure theory to spectral simulation, reactivity, transition states, and excited states; statistical mechanics of order-disorder transitions.

Major Instrumentation
Chemistry research spans all areas: analytical, biochemical, inorganic, physical, and polymer. Special equipment available for graduate research in chemistry is as follows.

Biochemistry research facilities—HPLCs, GCs, FPLC, ultracentrifuges, DNA synthesizer, scintillation and gamma counters, cold rooms, cell disintegrator, zone and disc electrophoresis apparatus, column chromatograph, autoclave, ultra-low temperature freezers (~90° and ~153°C), rotary vaporator, Milli-Q water purification system, shaking heated water baths, spectropolarimeter with circular dichroism capability. Cell culture facilities—complete with optical microscopes having fluorescent and photographic capabilities, liquid scintillation equipment. Catalysis facility—fully automated high pressure reactors with on-line gas chromatographs. Coal research and analysis facility—complete with ultracentrifuge, gas chromatographs, gel permeation chromatograph, vapor pressure osmometer, dry boxes. Electron optical facilities—transmission electron microscopy with x-ray fluorescence analysis capability, scanning electron microscope, and scanning
electron microprobe. Gas chromatographs, including a PE sigma 3 for inverse gas chromatography. Liquid chromatographs—
high performance for analytical and preparative work. NMR
spectrometers—90 MHz multinuclear, 300 MHz solid state, 360
MHz for solutions and imaging, 500 MHz spectrometer for
solutions. Photochemistry equipment—lamps and filters for
selected wavelength work. Polarographs,
chromopotentiometers, spectrophoresis apparatus,
electrochemical impedance, electrochemical scanning tunneling
microscopy, potentiostats, and rotating disk electrode. Titration
equipment (automated and computer interfaced), portable data
interface (8-channel 50 KHz), digital readout polarimeter, Vibron
elastoviscometers, radio-tracer equipment, including a gamma
counter, differential refractometer, rheometer. Spectrometers—uv/
visible double beam automated, uv/visible/near ir, Fourier
transform ir with diffuse reflectance, photoacoustic and
attenuated total reflectance capability, laser Raman, GC mass
spectrometers, time-of-flight (TOF) mass spectrometer with
$^{25}$CF desorption source. Mössbauer spectrometer, position
annihilation spectrometer. Surface analysis facilities—rotating
anode high-sensitivity high-energy resolution ESCA with
imaging capability (ESCA is equipped with automated angular
data acquisition). Surface science facility—Auger electron
spectroscopy, low energy electron diffraction (LEED), high
resolution electron energy loss spectroscopy (HREELS),
photocoloration spectroscopy for submicron particle analysis.
Ellipsometer, contact angle capabilities, gas adsorption apparatus
(BET), temperature programmed desorption (TPD), atomic force
microscope, instrumental scanning tunneling microscope, and
light scattering. Microcalorimeter (flowing with uv and refractive
index detectors), differential scanning calorimeter (DSC).
The NMR Laboratory is jointly operated with Air Products and
Chemicals and the ESCA Laboratory is jointly operated with
AT&T. A microcomputer laboratory consisting of 18 pentium-
based personal computers and a computer laboratory with five
SGI Octane workstations are jointly operated with LUIR.

Graduate Courses in Chemistry

Chm 400. Laboratory Safety (0) fall
Accident prevention; emergency response; government
regulations; facilities for handling and storage disposal of
hazardous materials; emergency facilities; liabilities. Lectures,
multi-media presentations, hands-on training by practitioners.

Chm 402. Physical Inorganic Chemistry (3) alternate years
Aufbau principle and coupling of angular momenta is used to
describe atomic and molecular term states. Group theoretical
principles will be utilized in studies of molecular orbital and
ligand field theories of bonding. Prerequisite: Chm 341 or
equivalent. Klier

Chm 403. Advanced Topics in Inorganic Chemistry (1-3)
alternate years
Topics of contemporary interest in inorganic chemistry. This
course may be repeated when a different topic is offered.
Prerequisite: Chm 307 or equivalent.

Chm 405. Organometallic Chemistry (3) alternate years
The chemistry of compounds containing carbon to metal bonds.
Among topics covered are the following: organic compounds of
the representative elements from Group I to IV; the chemistry of
ferrocene and related pi-bonded organometallic complexes;
metal carbonyl and nitrosyl complexes; dioxygen and dinitrogen
complexes; organic synthesis utilizing organometallic catalysts.
Kraihanzel

Chm 411. Teaching Internship (3-6) fall-spring
The preparation, teaching and grading of one or two
undergraduate lecture courses with appropriate supervision by
senior faculty members. Observation and evaluation of the
intern is effected by classroom visits and videotape review.
Prerequisite: candidacy in the doctor of arts program or
permission of the department chair. May be repeated for credit.

Chm 421. Chemistry Research (1-6)
Research in one of the following fields of chemistry: analytical,
inorganic, organic, physical, polymer, biochemistry.

Chm 423. Bio-organic Chemistry (3) alternate years
An examination of biochemistry on the basis of organic chemical
principles. Emphasis on reaction mechanisms of biochemical
transformations and methods for elucidation of these
mechanisms, i.e., kinetics, isotope effects, exchange techniques,
inhibition studies, substrate analog effects and organic model
studies. Prerequisite: Chm 358. Schray

Chm 424. Medicinal and Pharmaceutical Chemistry (3)
alternate years
Principles of drug design, structure-activity relationships in
antibacterial, antimalarial, anti-inflammatory and psychoactive
drugs; synthesis and modes of action of pharmacologically active
agents radioactively. Prerequisite: one year of
organic chemistry. Heindel

Chm 430. Chemical and Biochemical Separations (3) spring, alternate years
Theory and applications of equilibrium and nonequilibrium
separation techniques at both the analytical and preparative
levels. Solvent and buffer extractions, chromatographic
separations (e.g., thin layer, partition, gas liquid, gel filtration, ion
exchange, affinity, supercritical fluid), electrophoretic separations
(e.g., gel, capillary, isoelectric focusing, immunoelectrophoresis),
centrifugal separations (e.g., differential, velocity sedimentation,
density gradient) and other separation methods (e.g., dialysis,
ultrafiltration). Examples may be applied to biological applications.
Alhadeff

Chm 431. Contemporary Topics in Analytical Chemistry (1)
Discussion of the current literature in analytical chemistry,
including spectrometry, separations, and electrochemistry.
Students find current papers and lead discussions. May be
repeated for credit.

Chm 432. Chemometrics (3) fall, alternate years
Mathematical and statistical methods for experimental design,
calibration, signal resolution, and instrument control and
optimization. Freund

Chm 433. Electroanalytical Chemistry (3) alternate years
Theory and applications of selected electrochemical techniques;
solutions to mass transport problems, treatment of electron
transfer kinetics and kinetics of associated chemical reactions,
and critical evaluation of adsorption and other factors associated
with electrochemical processes. Prerequisite: Chm 332 or
equivalent. Freund

Chm 434. Advanced Topics in Spectroscopy (3) fall, alternate years
Fundamentals of interactions of electromagnetic radiation with
matter: electronic, vibrational, scattering based spectroscopies,
instrumentation and signal processing. Advanced applications to
the analysis of molecular structure and chemical processes
including surface analysis, time-resolved spectroscopies, and
ultrasensitive spectroscopic techniques. Messmer

Chm 435. Advanced Topics in Clinical Chemistry (3)
Selected areas of clinical chemistry such as chemical toxicology,
pathogenic microbial biochemistry in vivo diagnostic methodology,
therapeutic drug monitoring, or other advanced topics.
May be repeated for credit when a different topic is offered.
Chemistry 117

Chm 436. Special Topics in Analytical Chemistry (1-3) Topics of contemporary interest in analytical chemistry. May be repeated for credit when a different topic is offered.

Chm 437. (BioS 437) Pathophysiological Chemistry (3) spring Biochemical basis of human diseases involving abnormal metabolism of proteins, nucleic acids, carbohydrates, and lipids. Emphasis on the correlation of the clinical presentation of disease processes seen as physiological dysfunctions with clinical laboratory methods. Lectures, student presentations, and clinical case discussions. Prerequisite: consent of the department chair. Alhadeff

Chm 438. Advanced Topics in NMR (3) spring, alternate years Fundamental aspects of NMR analysis; instrumental design; data acquisition and processing parameters; nuclear spin relaxation; theory of spin dynamics; product operator formalism; density matrix theory; multidimensional methods; analysis strategies. Roberts

Chm 441. Chemical Kinetics (3) alternate years A study of kinetic processes. Phenomenological chemical kinetics; order, mechanism effect of external variables on rate. Theories of the rate constant. Relation between thermodynamics and kinetics. Applications to selected systems such as unimolecular decompositions, molecular beams and diffusion-limited processes. Prerequisite: one year of physical chemistry.

Chm 443. (Mat 443) Solid-State Chemistry (3) alternate years Crystal structure, diffraction in crystals and on surfaces, bonding and energy spectra in solids dielectrics, surface states and surface fields in crystals. Prerequisite: one course in linear algebra and one course in quantum mechanics. Klier

Chm 445. Elements of Physical Chemistry (4) Quantum chemistry of simple systems, molecular structure and spectroscopy, statistical and classical thermodynamics. Prerequisite: Chm 341 or its equivalent.

Chm 451. Physical Organic Chemistry (3) alternate years An introduction to quantitative organic chemistry including relationships between structure and reactivity, medium effects on reactions, introduction to orbital symmetry effects in organic reactions, and reaction mechanisms. Prerequisite: Chm 358 or consent of department chair. Larsen

Chm 453. Heterocyclic Compounds (3) alternate years An intensive study of the syntheses, reactions and properties of heterocyclic compounds including derivatives of thiophene, pyrrole, furan, indole, pyridine, quinoline, the azoles and the diazines — all considered from the viewpoint of modern theories of structure and reaction mechanisms. Prerequisite: Chm 358.

Chm 455. Organic Reactions (3) alternate years Intensive survey of modern synthetic organic chemistry from a mechanistic standpoint. Classical Name-reactions, olefin synthesis, organometallic reagents in synthesis, Woodward-Hoffmann rules, electrocyclic processes, enolate chemistry, and related reactions. Prerequisite: Chm 358.

Chm 456. Spectral Analysis (3) fall Use of data from nuclear magnetic resonance, infrared, ultraviolet, and mass spectrometric techniques for the determination of structure of organic compounds. Emphasis on information from one- and two-dimensional proton and carbon NMR, and a mechanistic interpretation of data from mass spectrometry. Foster

Chm 457. Organic Reaction Mechanisms (3) Intensive in-class problem solving that involves the formulation of reasonable reaction mechanisms for complex multistep pathways, i.e. organic transformations that proceed via highly energetic intermediates such as carbocations, carbanions, free radicals, carbenes, and nitrenes.

Chm 458. Topics in Organic Chemistry (1-3) An intensive study of limited areas in organic chemistry. May be repeated when a different topic is offered.

Chm 466. Advanced Organic Preparations (2-3) A laboratory course of instruction in advanced techniques of the preparation of organic compounds.

Chm 467. (BioS 467) Principles of Nucleic Acid Structure (3) alternate years An examination of the principles underlying nucleic acid structure including stereochemistry, electrostatics, hydration, torsional constraints, sequence specific effects, and interaction with nuclear proteins. Special emphasis will be placed on DNA structure. Prerequisite: one year of biochemistry and one year of physical chemistry or permission of the department chair. Behe

Chm 468. (BioS 468) Principles of Protein Structure (3) alternate years An examination of the principles underlying protein structure including stereochemistry, preferred tertiary structures, protein homology, excluded volume effects, time dependent structural fluctuations, and prediction of protein structure from sequence information. Prerequisite: one year of biochemistry and one year of physical chemistry or permission of the department chair. Behe

Chm 469. (BioS 469) Biochemical Problem Solving I (1) fall Applications of material covered in BioS / Chm 371 including techniques used in research. Prerequisite: BioS / Chm 371 previously or concurrently.

Chm 470. (BioS 470) Biochemical Problem Solving II (1) spring Applications of concepts covered in BioS / Chm 372 including techniques used in research. Prerequisite: BioS / Chm 372 previously or concurrently.

Chm 471. (BioS 471) Eucaryotic Biochemistry (3) alternate years Biochemistry of selected eucaryotic processes including hormone chemistry, blood clotting, immunochemistry, vision chemistry, muscle chemistry and photosynthesis. The second part of the course will involve presentation and discussion of the current literature by class participants. Prerequisite: BioS / Chm 372 or consent of department chair. Lowe-Krentz

Chm 472. (BioS 472) Lipids and Membranes (3) alternate years Structure, physical properties and functions of lipids and their biological aggregates. Techniques for studying lipid assemblies, enzymes which act on lipids, membrane proteins and lipoproteins will also be discussed. Prerequisite: BioS / Chm 372 or consent of department chair. Lowe-Krentz

Chm 473. (BioS 473) Biochemistry of Complex Carbohydrates (3) alternate years Consideration of the structure, function and metabolism of complex carbohydrates (glycolipids, glycoproteins and proteoglycans) with particular emphasis on glycoproteins. The first part of the course will consist of lectures to familiarize the student with basic terms, concepts and processes. The second part will involve critical readings, presentation and discussion of the current primary research literature by class participants. Alhadeff

Chm 475. Advanced Topics in Chemistry (1) Audiovisual courses in topics such as acid-base theory, NMR, chromatography, electroanalytical chemistry and mass-spectroscopy interpretation; course material obtained from the American Chemical Society. May be repeated for credit.
Chm 477. (BioS 477) Topics in Biochemistry (1-3)
Selected areas of biochemistry, such as mechanisms of enzyme action, new developments in the chemistry of lipids, nucleic acids, carbohydrates, and proteins. May be repeated for credit when different topics are offered. Prerequisite: consent of the department chair.

Chm 479. (BioS 479) Biochemical Techniques (3)
Laboratory studies of the techniques and principles involved in the isolation, identification, and biochemical transformation of carbohydrates, lipids, nucleic acids and proteins. Prerequisite: Chm 371 or its equivalent previously or concurrently.

Chm 480. (BioS 480) Advanced Biochemical Preparations (1-3)
An advanced laboratory course in the preparation, isolation, purification, and identification of biochemically produced materials. Emphasis is placed on materials and procedures of current interest in biochemistry. Prerequisite: consent of the department chair.

Chm 481. Chemistry Seminar (1-6)
Student presentations on current research topics in the student's discipline but not on subjects close to the thesis. A one-hour presentation and attendance at other presentations are required for credit. May be repeated for credit, up to six times.

Chm 482. (CHE 482, Mat 482) Engineering Behavior of Polymers (3) spring
Mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizer, moisture, and aging on mechanical behavior.

Chm 483. (CHE 483) Emulsion Polymers (3) fall
Fundamental concepts important in manufacture, characterization, and application of polymer latexes. Topics include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation and various application problems. Prerequisite: previous course in polymers. El-Aasser.

Chm 484. (CHE 484) Crystalline Polymers (3) spring
Morphology and behavior of both polymer single crystals and bulk crystallized system. Relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. Thermodynamics and kinetics of transition phenomena and a brief treatment of hydrodynamic properties and their relationship to crystallization and processing properties.

Chm 485. (CHE 485, Mat 485) Polymer Blends and Composites (3) fall
Synthesis, morphology and mechanical behavior of polymer blends and composites. Mechanical blends block and graft copolymers, interpenetrating polymer networks, polymer impregnated solids and fiber and particulate-reinforce polymers are emphasized. Prerequisite: any introductory course in polymers. Sperling.

Chm 487. Topics in Colloid and Surface Chemistry (3)
Applications of colloid chemistry; special topics in surface chemistry. Lectures and seminar. May be repeated for credit as different topics are covered. Prerequisite: Chm 391.

Chm 488. Advanced Topics in Physical Chemistry (1-3)
Advanced topics in physical chemistry, such as photochemistry and molecular beam dynamics, Fourier transform spectroscopy, kinetics of rapid reactions, theory of magnetic resonance, liquids and solutions. May be repeated for credit when different topics are offered.

Chm 489. Organic Polymer Science II (3) alternate years
Continuation of Chm 394. Theory and mechanism of ionic vinyl-addition chain-growth polymerization. Chain copolymerization by radical and ionic mechanism. Mechanism of ring-opening polymerization, stereochemistry of polymerization including ionic, coordination, and Ziegler-Natta mechanisms. Reactions of polymers, including crosslinking, reaction of functional groups, graft and block copolymers, and polymer carriers and supports. Prerequisite: Chm 394 or equivalent.

Chm 491. Physical Chemistry of Organic Polymer Coatings (3) alternate years
Pigment/bonder geometry. Oil absorption of pigments. Critical Pigment Volume Concentration concept. Pigment dispersion including surface tension, capillarity, works of dispersion, transfer and flocculation, and dispersing-mixing equipment. Solubility parameter concept. Coating viscosity and viscometers. Evaporation of solvents including water. Coating rheology, mill base letdown, and pigment settling. Film application including leveling, sagging, slumping and draining. Prerequisite: Chm 393 or 394 or equivalent.

Chm 492. (CHE 492) Topics in Polymer Science (3)
Intensive study of topics selected from areas of current research interest such as morphology and mechanical behavior, thermodynamics and kinetics of crystallization, new analytical techniques, molecular weight distribution, non-Newtonian flow behavior, second-order transition phenomena, novel polymer structures. Credit above three hours is granted only when different material is covered. Prerequisite: Chm 392 or equivalent.

Chm 493. Organic Chemistry of Organic Polymer Coatings (3) alternate years
Film information from solution and dispersion, and application of coatings. Mechanism and kinetics of curing glycride oils, varnishes and alkyd resins, unsaturated polyesters, thermoplastics cellulose, acrylic and vinyl resins, epoxy resins, polyurethanes, amine- and phenol-formaldehyde resins, thermosetting vinyl and acrylic copolymers, water-based systems, natural and synthetic rubber, and silicone resins. New solutions coatings. Prerequisite: Chm 393 and 394 or equivalent.

Chm 494. Quantum Chemistry (3) alternate years
Principles and applications of quantum mechanics to chemical problems. Applications to chemical bonding, molecular structure, reactivity and spectroscopy. Prerequisite: Chm 445 or consent of the department chair.

Chm 495. Statistical Thermodynamics (3) alternate years
Principles and applications of statistical mechanics to chemical problems. A study of the techniques for evaluating the properties of matter in bulk from the properties of molecules and their interactions. Prerequisite: Chm 445 or consent of the department chair.

Civil and Environmental Engineering

Professors, Arup K. SenGupta, Ph.D. (Houston), chair; Gerard P. Lennon, Ph.D. (Cornell), associate chair; John L. Wilson, Ph.D. (Pittsburgh); graduate officer; John W. Fisher, Ph.D. (Lehigh), Joseph T. Stuart Professor and director, Center for Advanced Technology for Large Structural Systems; Le-Wu Lu, Ph.D. (Lehigh); Celal N. Kostem, Ph.D. (Arizona); Robert M. Sorensen, Ph.D. (U.C. Berkeley); Richard N. Weisman, Ph.D. (Cornell); Ben-Tseng Yen, Ph.D. (Lehigh).
Recommended Sequence of Courses

Freshman Engineering year (see Section III)

Sophomore Year, first semester (18 credit hours)
Math 23 Analytic Geometry and Calculus III (4)
EES 101 Geology for Engineers (3)
Mech 2 Elementary Engineering Mechanics (3)
CE 14 Measurements and Problem Solving in Civil Engineering (4)
Eco 1 Principles of Economics (4)

Sophomore Year, second semester (17 credit hours)
Math 205 Linear Methods (3)
Mech 12 Strength of Materials (3)
CE 15 Graphics for Civil Engineering (3)
Phys 21 Introductory Physics I (4)
Phys 22 Introductory Physics Lab II (1)
HSS Humanites/Social Sciences Elec. (3)

Junior Year, first semester (17 credit hours)
Mat 192 Structural Materials (3)
CE 121 Mechanics of Fluids (3)
CE 143 Soil Mechanics (4)
CE 159 Structural Analysis I (4)
HSS Humanities/Social Sciences Elec. (3)

Junior Year, second semester (17 credit hours)
CE 117 Numerical Methods in Civil Engineering (2)
CE 160 Structural Design (4)
CE 222 Hydraulic Engineering (4)
CE 270 Introduction to Environmental Engineering (4)
Engineering Science Elective (3)

Senior Year, first semester (17 credit hours)
CE 202 CE Planning and Engineering Economics (3)
CE 203 Professional Development (2)
HSS Humanites/Social Sciences Elec. (3)
Approved Electives (6)
Free Elective (3)

Senior Year, second semester (18 credit hours)
CE 207 Transportation Engineering (3)
CE 290 CE Design Project (3)
HSS Humanities/Social Sciences Elec. (3)
Approved Electives (6)
Free Elective (3)
*Mech 102, ME 104, or ECE 81

Elective opportunities total 36 credit hours. The selection of elective courses is to be in consultation with the student’s academic adviser in the Department of Civil and Environmental Engineering. A total of 135 credit hours is required for the degree in civil engineering.

Undergraduate Courses

CE 14. Measurements and Problem Solving in Civil Engineering (4) fall
An introduction to civil engineering, including problem solving in the specialty areas of environmental, geotechnical, hydraulic, and structural engineering; presentation of typical civil engineering problems followed by selected laboratory exercises emphasizing fundamental concepts. Theory and practice of basic engineering surveying measurements including angles, distances, and elevations; systematic and random errors; error compensation; concepts of probability and probability distributions; propagation of errors; estimation of mean and variance from sample observations; random variable correlation; testing of hypothesis. Emphasis will be on applications relating to a range of civil engineering activities. Prerequisite: Math 22 (ES 2), (ED 0)

CE 15. Graphics for Civil Engineering (3) spring
Basic theoretical and technical study of computer graphics systems with practical applications in civil engineering. Theory of orthographic and perspective projection. Problems of point, line, and plane in descriptive geometry. Emphasis on visualization and geometric logic. Prerequisites: Engr 1, (ES 0), (ED 0)

CE 104. Readings in Civil Engineering (1-4)
Study of selected technical papers, with abstracts and reports. May be repeated for credit. Prerequisite: consent of the department chair.

CE 117. Numerical Methods in Civil Engineering (2) spring
Techniques for computer solution of linear and non-linear simultaneous equations; eigenvalue analysis; finite differences; numerical integration; numerical solutions to ordinary differential equations. Case studies in the various branches of civil engineering. Prerequisites: Engineering 1, Math 205. (ES 2), (ED 0)
CE 121. Mechanics of Fluids (3) fall
Fluid properties and statics; concepts and basic equations for fluid dynamics. Forces caused by flowing fluids and energy required to transport fluids. Dynamics similarity and modeling of fluid flows. Includes laboratory experiments to demonstrate basic concepts. Prerequisite: Mech 2. (ES 3), (ED 0)

CE 140. Special Topics in Surveying (3) spring
Geodetic coordinates, map projections, triangulation, photogrammetry, construction surveys, hydrographic surveys, underground surveys, adjustment of horizontal and vertical control nets, precise leveling, doppler satellite surveys, and aerial pollution control surveys. Field and office work. Prerequisite: CE 14. Limited enrollment. (ES 3), (ED 0)

CE 143. Soil Mechanics (4) fall
Fundamental physical, chemical and mechanical properties affecting the engineering behavior of soils. Identification; classification; permeability; effective stress and pore water pressures; compaction, compression and consolidation; stress-strain behavior and shear strength; laboratory tests for engineering properties; application of theories and principles in engineering practice. Prerequisite: Mech 12 or consent of the department chair. (ES 3.5), (ED 0.5)

CE 159. Structural Analysis I (4) fall
Elastic analysis of statically determinate beams, frames, and trusses; deflections by the methods of virtual work and moment area; influence lines for determinate structures; modeling for structural analysis; flexibility, stiffness, and approximate methods of analysis of indeterminate structures. Prerequisite: Mech 12. (ES 4), (ED 0)

CE 160. Structural Design (4) spring
Principles of structural design. Safety and economy. Strength, stability and serviceability criteria. Selection of simple structural members to resist tensile, compressive, bending, and shearing loads. Various structural materials will be covered, especially steel and reinforced concrete. Prerequisite: CE 159. (ES 1), (ED 3)

CE 172. Fundamentals of Environmental Pollution (3)
Introduction to water, air, noise, solid waste, radiation and hazardous substance pollution problems. Regulatory standards and rationale, risk and hazardous assessment, economic consequences, technology for control. (ES 3), (ED 0)

CE 202. CE Planning and Engineering Economics (3) fall
The planning and management of civil engineering projects. Modeling and optimization methods, project management techniques. Financial decision-making among alternatives. Present value and discounted cash flow analysis; incremental analysis and rate-of-return criteria. (ES 1), (ED 2)

CE 203. Professional Development (2) fall
Elements of professionalism; professional ethics; engineering registration; continuing education; responsibilities of an engineer in industry, government, private practice; role of professional and technical societies. Prerequisite: consent of the department chair. (ES 0), (ED 0)

CE 205. Design Problems (1-6)
Supervised individual design problems, with report. Prerequisite: consent of the department chair.

CE 207. Transportation Engineering (3) spring
Principles of the design of transportation facilities with emphasis on highways and airports in the areas of geometric, drainage, and pavement design. Design problems. Prerequisites: CE 14 and senior standing. (ES 0), (ED 3)

CE 211. Research Problems (1-6)
Supervised individual research problems, with report. Prerequisite: consent of the department chair.

CE 215. Probability and Statistics in Civil Engineering (3) fall
Basic concepts of probability; probability distributions; estimation of parameters; regression and correlation. Analysis of stochastic engineering data. Emphasis on applications to civil engineering problems; structural stability, random loading, risk analysis, traffic flow and water-resource problems, hazard assessment for toxic materials. Prerequisites: Math 23, Mech 12, previously or concurrently. (ES 1), (ED 0)

CE 217. Computer Integrated Civil Engineering Systems (3) spring
Basic characteristics of modern interactive analysis and design systems. Data structures; 2-D and 3-D graphics modeling; user interfaces; integrated analysis / graphics / data management. Decision tables. Introduction to knowledge-based systems and artificial intelligence. Numerous case studies and use of interactive systems. In-depth experience with computer-integrated systems. (ES 0), (ED 1)

CE 222. Hydraulic Engineering (4) spring
Flow measurements, pipe hydraulics, open-channel flow and river engineering, hydraulic structures and model studies. Laboratory experiments in applied hydraulics. Prerequisite: CE 121. (ES 2), (ED 2)

CE 223. Hydraulics for Earth and Environmental Scientists (3) spring, alternate years
Basic fluid mechanics and hydraulics for non-engineers. Topics include: fluid statics; conservation of mass, energy and momentum; boundary layer flow and fluid drag; flow in pipelines and pumps; open channel flow; groundwater flow; hydrologic analysis; and coastal processes. Prerequisite: Basic courses in calculus and physics.

CE 244. Foundation Engineering (3) spring
Application of theories and principles of soil mechanics to foundation design of constructed facilities. In-situ soil test and measurement, subsurface exploration and soil sampling. Bearing capacity, settlement, lateral earth pressure principles. Design of shallow foundations: spread footings, beams on elastic foundations, mat foundations. Design of retaining walls: mechanically stabilized earth, concrete and sheet pile walls, walls for excavations. Design of deep foundations: single piles, pile foundations, drilled piers and caissons. Prerequisite: CE 143. (ES 1.5), (ED 1.5)

CE 258. Structural Laboratory (3) spring
Experimental study of behavior of members and structures. Planning, executing, and reporting experimental studies. Introduction to instrumentation and data acquisition. Nondestructive testing of civil engineering structures. Steel, reinforced concrete, and other materials. Prerequisite: CE 160. (ES 2), (ED 1)

CE 259. Structural Analysis II (3) spring
Analysis of statically indeterminate structures, methods of slope deflection and moment distribution; consideration of side-way and nonprismatic members. Influence lines for determinate and indeterminate structures. Flexibility and stiffness matrix methods for computerized analysis. Use of computer library programs. Prerequisite: CE 159. (ES 3), (ED 0)

CE 261. Structural Steel Design (3) fall
Design of steel structures, including plate girders, other built-up members, trusses, frames, grillages, shell-type structures and thin-gage members. Additional topics include connections, composite beams, and fatigue and fracture concepts related to structural design. Prerequisite: CE 160. (ES 0.5), (ED 2.5)
**Civil and Environmental Engineering**

**CE 263. Structural Concrete Design (3) fall**
Design of reinforced concrete structural members and simple systems, including continuous beams, columns, frames, one-and two-way slabs, and footings. Deflection, cracking, and column slenderness. Introduction to prestressing and torsion. Prerequisite: CE 160. (ES 1), (ED 2)

**CE 266. Project Management (3) spring**
An overview of the management and control of engineering ventures and projects. Emphasis on systems theory, life-cycle approach, resource management, financial controls, contracts, labor relations and organizational forms. Case studies and lectures from industry. Prerequisite: CE 202 or consent of the department chair. (ES 1), (ED 2)

**CE 270. Introduction to Environmental Engineering (4) spring**
Characterization and evaluation of natural water resources. Principles of basic water chemistry. Water and wastewater treatment processes. Sludge treatment, air pollution and multimedia transport. Pollutants mass balance and oxygen transfer. Field trips to water and wastewater process facilities. Laboratory experiments on water and wastewater characterization. Prerequisites: Chem 21, (ES 2), (ED 2).

**CE 281. Special Topics (1-6)**
A study of selected topics in civil and environmental engineering not included in other formal courses. A design project or an interdisciplinary study of a problem related to civil or environmental engineering may be included. Civil and environmental engineering students working on design projects involving students from other departments or colleges working in cross-disciplinary teams may be included. A report is required. Prerequisite: consent of the department chair.

**CE 290. CE Design Project (3) spring**
Supervised design projects applying the fundamentals of engineering science and the concepts of planning and systems analysis in the design of practical engineering works. The scope includes needs analysis, formulation of the design problem statement and evaluative criteria, analysis of alternative solutions and the generation of specifications. Economic, social, environmental, aesthetic and safety constraints are considered. Practicing professional engineers are invited to serve as consultants. Written and oral reports are required. Prerequisite: Senior standing. (ES 0), (ED 3)

**CE 320. Flood Hydrology and Hydraulic (3) fall**
Rainfall-runoff analysis, overland flow, hydrograph theories, modeling. Frequency analysis of extreme events. Flood routing. Design storms. Floodplain hydraulics, floodplain delineation. Prerequisite: CE 222. (ES 2), (ED 1)

**CE 321. Open Channel Hydraulics (3) fall**
Energy and momentum concepts, frictional resistance in open channels. Rapidly and gradually varied flow in open channels; unsteady flow in open channels; channel and culvert design. Prerequisite: CE 222. (ES 2), (ED 1)

**CE 322. Hidromechanics (3)**
Ideal fluid flow, vortex flow, creeping motion; laminar boundary layers, turbulent shearing stress and turbulent boundary layers; turbulent jets and diffusion. Prerequisites: Math 205 and CE 222. (ES 3), (ED 0)

**CE 324. (Mech 323) Fluid Mechanics of the Ocean and Atmosphere (3)**
Hydrostatics of the ocean and atmosphere. Vertical stability. Fluid motion in a rotating coordinate system. Geostrophic flow; ocean currents; surface and internal waves. Prerequisite: ME 231 or CE 121.

**CE 326. Engineering Groundwater Hydrology (3) spring**
The study of subsurface water, its environment, distribution, and movement. Also included are hydraulics of pumping wells, sea water intrusion, artificial recharge, and an introduction to the movement of contaminants. A design project is included to simulate drawdown and movement of contaminants in a regional aquifer using a finite-difference model. Prerequisite: CE 222. (ES 2), (ED 1)

**CE 327. Surface Water Quality Modeling (3) spring**
Fundamentals of modeling water quality parameters in receiving water bodies, including rivers, lakes, and estuaries. Modeling of dissolved oxygen, nutrients, temperature, and toxic substances. Emphasis on water quality control decisions as well as mechanics and model building. Prerequisites: CE 121, CE 222 and CE 270. (ES 3), (ED 0)

**CE 335. Coastal Engineering (3) fall**
Linear wave theory and wave characteristics; survey of nonlinear theories; tides, tsunamis, storm surge and basin resonance; wind-generated wave spectra, statistics and forecasting; wave-structure interaction; nearshore circulation and sediment transport; interaction of littoral processes with structures. Prerequisite: CE 121. (ES 2), (ED 1)

**CE 336. Harbor and Coastal Engineering Design (3) spring**
Team design approach to the preliminary design and cost analysis of a harbor and coastal engineering project. Project components typically include: definition of wave, surge and tide conditions; layout of harbor and ancillary navigation channels; design of all harbor and coastal structures; control of potential erosion problems; establishment of dredging requirement; description of anticipated environmental impacts; and estimate of project costs. Each team will prepare a design report with necessary drawings and make an oral presentation. Prerequisite: CE 335. (ES 0), (ED 3)

**CE 341. Ground Improvement Engineering (3) spring**
The mechanisms of soil stabilization; principles and techniques; grouting and injection methods; reinforced earth methods, dynamic consolidation; deep compaction; sand drains; laboratory and field studies; geotextiles and geomembranes. Prerequisite: CE 143 or equivalent. (ES 1.5), (ED 1.5)

**CE 342. Experimental Geotechnical Engineering (3) fall**
Experimental studies dealing with the measurement of soil properties in the laboratory and in situ; application of these properties to design; consolidation; strength of soils in triaxial compression, tensile strength, and other shear tests, including measurement of pore water pressures; model design and analysis; dynamic tests; field measurement in situ soil properties; laboratory and field instrumentation. Prerequisites: CE 143 and senior standing. (ES 1.5), (ED 1.5)

**CE 343. Seepage and Earth Structures (3) spring**
Long- and short-term stability of embankments and cut slopes; numerical and graphical methods of stability analysis; seepage through soil; design of earth dams, embankments and excavations; influence of embankment stability; construction control, field measurement of pore pressures and earth movements; model studies. Prerequisite: CE 143 or equivalent. (ES 2), (ED 1)

**CE 344. Behavior of Soils as Engineering Materials (3) spring**
Soil mineralogy, bonding, crystal structure and surface characteristics; clay-water electrolyte system; soil fabric and its measurement; soil structure and physical property relationships; soil depositional and compositional characteristics; engineering properties of soils as they relate to soil mineralogy, fabric and composition; volume change behavior, intergranular stresses,
shear strength and deformation behavior, conduction behavior, coupled and direct flow phenomena. Prerequisite: CE 143. (ES 3), (ED 0)


CE 346. Fundamentals of Designing with Geosynthetics (3) spring Fundamental and current theories of designing soil structures with geosynthetics. Roads and highway applications; reinforced embankments; slope stabilization; waste containment systems; erosion control; filtration and drainage. Prerequisite: CE 143. (ES 1.5), (ED 1.5)


CE 359. Plastic Analysis and Design (3) spring Plastic analysis and design of steel structures. Strength and behavior of frames and component parts beyond the elastic limit. Methods of predicting strength and deformation in the plastic range. Studies of industrial and multisistory frames. Comparison of plastic design techniques with allowable-stress design methods. Current research. Prerequisite: CE 250 or consent of the department chair. (ES 2), (ED 1)

CE 360. Structural Engineering Project (3) spring Team approach to the design of structures including bridges, buildings, or other structures in steel, reinforced concrete, or prestressed concrete. Project includes conceptual and preliminary design, preliminary cost analysis, and detailed final design and cost analysis. All aspects of the structure are treated including foundations, substructure, and superstructure, considering requirements of economy, strength and in-service performance. Prerequisites or co-requisites: CE 259, CE 261 and CE 263. (ES 0), (ED 3)

CE 365. Prestressed Concrete (3) spring Principles of prestressing. Analysis and design of basic flexural members. Instantaneous and time-dependent properties of materials. Prestress losses. Additional topics may include continuity, partial prestressing, compression members, circular prestressing, etc. Prerequisite: CE 263 or consent of the department chair. (ES 2), (ED 1)

CE 370. Environmental Engineering Processes (3) spring Processes applied in environmental engineering for air pollution control, treatment of drinking water, municipal wastewater, industrial wastes, hazardous/toxic wastes, and environmental remediation. Kinetics, reactor theory, mass balances, application of fundamental physical, chemical and biological principles to analysis and design. Prerequisite: CE 270 or equivalent. (ES 1), (ED 2).

CE 374. Environmental Water Chemistry (3) fall Chemical principles and applications of those principles to the analysis and understanding of aqueous environmental chemistry in natural waters and wastewaters. The chemistry of ionic equilibria, redox reactions, precipitation/dissolution, acid-base concepts, buffer capacity, complexation, hydrolysis and biological reactions. Laboratory experiments. Prerequisite: Chem 31 or equivalent, or CE 270. (ES 2), (ED 0)

CE 375. Environmental Engineering Laboratory (3) Application of laboratory-based techniques to solution of environmental engineering problems. Chemical and microbiological analysis for key pollution parameters. Use of small pilot and bench scale equipment to generate design parameters. Illustration of techniques for scale-up using parameter values generated in laboratory. Practice in use of automated instrumentation for analysis. Prerequisite: CE 370, previously or concurrently. (ES 1.5), (ED 1.5)

CE 378. Water Resources Engineering Design (3) spring Project-oriented design utilizing principles of hydraulics, hydrology and environmental engineering. Course will include lectures on selected water resource engineering topics and a design project. Prerequisites: CE 222 and either CE 320 or 321. (ES 0), (ED 3)

CE 381. Special Topics (1-3) A study of selected topics in civil engineering, not included in other formal courses. A report is required. Prerequisite: consent of the department chair.

CE 385. Research Procedures Seminar (1) fall Planning and execution of research projects, survey of current research, elements of proposals and budgets. Literature search procedures. Presentation of data, and of written and oral reports. Guidelines for visual aids.

Graduate Programs
Graduate studies in civil and environmental engineering enable the student to build upon the broad background of undergraduate education in preparation for professional practice at an advanced level, for research and development, or for teaching.

The selection of graduate courses and research opportunities offered in the department permits the development of individual program objectives that may be concentrated in one of the technical specialty areas, or, alternatively, may extend over the broad field of civil engineering. The department offers advanced work in the specialty areas of structural engineering, geotechnical engineering, hydraulic engineering, hydrology, coastal engineering, and environmental engineering, leading to the degrees of master of science, master of engineering, and doctor of philosophy in civil engineering or environmental engineering.

A graduate program leading to the M.S. normally is concentrated in one, or possibly two, of the technical specialty areas, and consists of a number of courses designed to fulfill the individual student's program objectives. Each candidate for the M.S. is required to submit a thesis representing three to six credit hours (CE 491, listed below), or alternatively, a report based on a research course of at least three credits (CE 429, 439, 449, 469, 479 or 481). The balance of the program will consist of courses in the specialty area(s).

A graduate program leading to the M.Eng. degree stresses engineering applications and design. The courses may extend across the various specialty areas in civil engineering. Each candidate for the M.Eng. may choose to complete an individual engineering project representing three to six credits (CE 480) in place of the thesis or research report required for the M.S. or to take a minimum of 30 course credits without a research or design project.
The doctoral program, which leads to the Ph.D., normally includes courses in the major field, courses in minor fields, and a dissertation presenting results of original research. Holders of master's degrees planning to become candidates for the Ph.D. take a qualifying examination at the first opportunity following one semester in residence. After qualification, the program of work is formulated by the candidate, the candidate's departmental Ph.D. committee, and the department chair.

The laboratories of the department are located in the Fritz Engineering Laboratory. The laboratory offers outstanding facilities for research and instruction in structural engineering, geotechnical engineering, hydraulic engineering, hydrology, coastal engineering, environmental engineering, and related fields. In particular, the structural testing equipment includes dynamic testing machines, a five-million-pound universal hydraulic testing machine, and other special loading apparatuses. Included in the latter are the facilities of the Center for Advanced Technology for Large Structural Systems (ATLSS center) located on the mountain top section of the campus. These include the largest 3-dimensional test bed in the U.S.A. and specialized earthquake testing facilities. The hydraulic facilities include a wave tank, several flumes, a 10 cif recirculating flow system, and two multipurpose tanks for model studies. Brochures describing the research facilities and programs are available on request.

In addition to departmental courses, a number of courses offered by the departments of mechanical engineering and mechanics, chemistry, chemical engineering, materials science and engineering, earth and environmental sciences, and biology may also be considered a part of the major field in civil and environmental engineering. A list of such courses is available through the department chair.

A number of research assistantships and teaching assistantships are available to provide financial aid to students of outstanding promise. The half-time research or teaching activities required of holders of assistantships provides a valuable educational experience that supplements the formal course offerings. The graduate course offerings of the department are programmed to fit the schedule of half-time assistants, and to accommodate part-time students. A very limited number of scholarships and fellowships are available to provide financial aid for full-time study.

Graduate Courses in Civil Engineering

CE 405. Analytical and Numerical Methods I (3)
Analytical and numerical methods used in Civil Engineering, with emphasis on ordinary and partial differential equations. Analytical and numerical solutions of ordinary and partial differential equations. Initial and boundary value problems. Numerical integration, numerical error, and approximations of functions and data points. Finite differences, solution of systems of linear equations, eigenvalue problems, and solution of nonlinear equations. Prerequisite: Math 205 or equivalent.

CE 408. Computer Methods in Civil Engineering (3)
Numerical and computer-oriented methods specially applicable to the solution of complex problems arising in various fields of civil engineering. Solutions of well-and ill-conditioned linear and nonlinear systems. Eigenvalue formulation of stability and dynamic problems. Reduction techniques, integration schemes for large structural systems. Optimal design by linear programming. Introduction to problem-oriented languages and computerized design. Prerequisite: CE 405

CE 409. Finite Element Method in Structural Mechanics (3)
Spring
Basic principles and equations governing the finite element method. Analysis of planar, axisymmetric, plate and articulated structures, with emphasis on analytical modeling. Accuracy and convergence studies, utilizing different discretizations and various types of elements. Case studies include application and extension to material nonlinearities, bridges, containment vessels, and soil-structure interaction. Prerequisites: CE 405 and CE 413 or equivalent.

CE 412. Methodologies of Structural Design (2)
Probabilistic analysis of uncertainties associated with structural design. Characterization of loads including dead and live loads, wind, earthquake, and vehicular loads. Variability of structural resistance based on strength limit states as well as serviceability. Assessment of safety and reliability. Deterministic and probabilistic methodologies of design. Prerequisite: CE 215 or permission of instructor.

CE 413. Mechanics and Behavior of Structural Members (3)

CE 420. Surface Wave Mechanics (3)
Elements of hydrodynamics and wave boundary conditions; linear wave theory and wave characteristics; nonlinear wave theories and application; wind wave generation, analysis and prediction; long waves; design wave determination; laboratory investigation of surface waves. Prerequisites: consent of instructor.

CE 421. Advanced Topic in Hydraulics (1-3)
Recent developments in hydraulic and sediment transport. Topics to be selected from: wave mechanics, theory of water flow through porous media, dispersion, hydrodynamic forces on structures, potential flow, free streamline theory, open channel hydraulics, computer methods. Prerequisites: CE 322 and consent of the department chair. May be repeated for credit.

CE 422. Advanced Topics in Coastal Engineering (1-3)
Advanced study of selected topics in coastal engineering such as: non-linear wave theory, design of coastal structures, shore protection and stabilization, numerical solutions of coastal
Application of virtual work principles and development of displacement (stiffness) method of analysis in matrix form.

Introduction to second order theory of structural members and second order equations of structural analysis. Prerequisite: CE 259 or equivalent.

**CE 451. Advanced Structural Theory (3) fall**
Selected topics in structural theory: influence lines, multi-story building frames, space structures. Introduction to finite element method; nonlinear problems. Prerequisite: CE 450.

**CE 452. Fatigue and Fracture of Structures - An Interdisciplinary View (3)**
This course examines the fatigue and fracture characteristics of steel structures from metallurgical, mechanical and structural engineering views. Both theory and experimental background are provided and applied to case studies and code development.

**CE 453. Structural Members and Frames (3) fall**
General torsion of thin-walled open, closed, and combined open and closed cross-sections; general instability of thin-walled members; inelastic instability; special problems in stability.
Desirable preparation: Mech 415. Prerequisites: CE 405 and consent of the department chair.

**CE 454. Plate and Shell Structures (3)**

**CE 455. Advanced Structural Dynamics (3)**
Analysis and design of structures to resist wind, earthquake, and blast loading. Matrix methods and computer applications. Non-linear and elasto-plastic response. Damping characteristics of structures and structural components, spectral analysis, dynamic instability. Characteristics of aerodynamic and seismic forces and explosions. Introduction to vibration of three-dimensional structural systems. Prerequisites: CE 352 or Mech 406, CE 405 and CE 450 or equivalent.

**CE 456. Behavior and Design of Earthquake Resistant Structures (3)**

**CE 457. Theory and Design of Steel Structures (3)**
Analysis and design of steel structures; structural connections; composite steel-concrete systems and other components. Consideration of residual stress; brittle fracture; fatigue strength; fastener systems. Study of current research and application to design practice.

**CE 458. Repair and Retrofit of Steel Structures (3)**
Various types of construction problems experienced during fabrication, erection, and service of steel structures are examined. Problems include material related defects, repair of welds, mix matches, stability and erection related deformation. Case studies of failures and serious construction deficiencies are reviewed and evaluated.
CE 459. Advanced Topics in Plastic Theory (3) fall
Fundamentals of the mathematical theory of plasticity; the general theorems of limit analysis and their applications to beams under combined loading, arches, space frames, plates and shells. Limit analysis of two- and three-dimensional problems in soil, concrete, rock, and metal. Current developments. Prerequisite: CE 359.

CE 460. Experimental Methods in Structural Engineering (3) Study of methods and equipment used in a modern structural engineering research laboratory. Topics include small-scale modeling theory; operational and performance characteristics of transducers; detailed examination of specific transducers for measurement of strain, force, displacement, velocity, acceleration, and temperature; loading systems and controls; data acquisition and signal conditioning; introduction to nondestructive testing of structures.

CE 461. Advanced Bridge Engineering (3) Students in CE 461 cover the same topics described under CE 360, but in more depth. In addition each student conducts an intensive study of a bridge-related topic of his or her choice. A short written technical report on the findings of this study is required. Prerequisites: CE 261 and CE 263.

CE 464. (Mech 416) Analysis of Plates and Shells (3) Bending of rectangular and circular plates, plates under lateral loads, plates with thermal and inelastic strains, effect of in-plane forces, large deflections, buckling of plates. Geometry and governing equations of shells, shells of revolution, membrane states, edge solutions, solution by numerical integration, nonsymmetric problems, buckling of shells, applications to pressure vessels. Prerequisites: Math 205; Mech 305 or equivalent course in advanced mechanics of materials.

CE 465. Advanced Topics in Concrete Structures (3) fall Advanced topics in reinforced concrete with or without prestress. Analysis and design for torsion. Limit design concepts. Design of slab systems: strength design method, yield line theory and strip method. Other topics may include composite members, probabilistic basis of design codes, and building and bridge design. Prerequisites: CE 263 or equivalent, or consent of department chair.

CE 466. Concrete Shell Structures (3) Analysis and design of concrete shell structures. Folded plates, cylindrical shells, and shells of double curvature. Typical practical problems. Prerequisites: CE 405 and consent of the department chair.

CE 467. Advanced Topics in Structural Engineering (1-3) Advanced study of selected topics in structural mechanics and engineering, such as: finite element methods, suspension system; space frames; stability of nonlinear systems; coldformed and lightweight construction; optimization and reliability; second-order phenomena in structures; interaction of structures with the environment; structural use of plastics; composite construction, etc. Selection of topics will depend on particular qualifications of the staff, as well as on the interests of the students. Prerequisite: consent of the department chair. May be repeated for credit.


CE 469. Structural Research (1-6) Individual research with reports. May be repeated for credit.

CE 470. Reaction Kinetics in Environmental Engineering (2) Theory of reaction kinetics and its application to the design and operation of chemical, physico-chemical and biological reactors in water and wastewater treatment. Basic design equations for various types of reactors and migration of pollutants in the environment.

CE 471. Water Treatment Facilities (3) Theory and design of water treatment system components. Emphasis on coagulation, flocculation, sedimentation, filtration, and disinfection. Estimation of design parameters from laboratory experiments. Prerequisite: CE 370 or equivalent.


CE 473. (ChE 473) Environmental Separation and Control Theory and application of adsorption, ion exchange, reverse osmosis, air stripping and chemical oxidation in water and wastewater treatment. Modeling engineered treatment processes. Prerequisite: CE 470 or consent of the instructor.

CE 474. Aquatic Chemistry (3) Applying basic principles of aqueous chemistry for quantifying complex, environmental systems. Specific examples of air-water-soil interactions and consequent effects. Heterogeneous equilibria with more than one solid phase. Kinetics and thermodynamics of some important ionic and biological reactions. Prerequisite: CE 374.

CE 475. Advanced Topics in Environmental Engineering (1-3) Advanced concentrated study of a selected topic in environmental engineering such as non-point source pollution control, water reuse systems, new concepts in treatment technology, toxic substances control, etc. Topic is selected by the instructor and student. Courses may include specialized laboratory research, literature review, specialty conference attendance. Prerequisite: Department chair approval.


CE 477. Transport of Pollutants in Surface Waters (2) Fundamental models of pollution migration in streams, estuaries and oceans. Diffusion, mass transport, dispersion, biological, physical, and chemical interactions. Effects on water quality especially oxygen nutrient and toxics levels. Prerequisites: CE 470, 471, 472.

CE 478. Toxic and Hazardous Wastes (3) Regulations for collection, transportation, disposal and storage of hazardous wastes. Containment systems, monitoring, types of liners, new and available technologies to eliminate or recover the hazardous components of the wastes. Prerequisite: CE 370 or CE 374.

CE 479. Environmental Engineering Research (1-6) Individual research problems in environmental engineering with report. May be repeated for credit.
Civil Engineering and Earth and Environmental Sciences

This program is designed for students interested in geological engineering, and leads to two bachelor of science degrees, in civil engineering and in earth and environmental sciences, both awarded at the end of the fifth year. The program provides alternatives for students who may decide not to complete the two-degree program. Students who make this decision prior to the beginning of the fourth year may qualify at the end of that year for the bachelor of science in civil engineering, as well as a minor in earth and environmental sciences. Also, if a student decides after two years to pursue only the bachelor of science in earth and environmental sciences, it is possible to complete the requirements in four years. If the decision to work toward this degree is made during the fourth year, at least one additional semester is required to qualify for either bachelor degree. Interested students should consult with the associate chair in the department of civil engineering to adapt the rescheduling of courses to resolve conflicts or if a specified course is not offered that semester.

**freshman engineering year (see Section III)**

**second year, first semester (16 credit hours)**
Math 23 Analytic Geometry and Calculus III (4)
Mech 2 Elementary Engineering Mechanics (3)
Chm 31 Chemical Equilibria in Aqueous Systems (3)
EES 101 Geology for Engineers (3)
CE 15 Graphics for Civil Engineering (3)

**second year, second semester (18 credit hours)**
Phy 21 Introductory Physics II (4)
Phy 22 Introductory Physics Laboratory II (1)
Mech 12 Strength of Materials (3)
EES 113 Life and Climate in the Rock Record (3)
Math 205 Linear Methods (3)
CE 14 Measurements and Problem Solving in Civil Engineering (4)

**third year, first semester (16 credit hours)**
CE 121 Mechanics of Fluids (3)
CE 143 Soil Mechanics (4)
EES 122 Introduction to Plate Tectonics (3)
EES 133 Introduction to Mineralogy (3)
Mat 192 Structural Materials (3)

**third year, second semester (20 credit hours)**
CE 117 Numerical Methods in Civil Engineering (2)
CE 222 Hydraulic Engineering (4)

**fourth year, first semester (18 credit hours)**
CE 202 Civil Engineering Planning and Engineering Economics (3)
EES 301 Introduction to Geophysics (3)
EES 373 Geochemical Thermodynamics (3) or Chm 187 Physical Chemistry (3)
CE Civil Engineering Elective (3)**
EES 307 Case Histories in Engineering Geology (3)

**fourth year, second semester (16 credit hours)**
CE 160 Structural Design (4)
EES 112 Engineering Science Elective (3)*
EES 307 Case Histories in Engineering Geology (3)

**summer (6 credit hours)**
EES 341 Field Geology (6)

**fifth year, first semester (18 credit hours)**
CE 207 Transportation Engineering (3)
CE 290 Civil Engineering Design Project (3)
CE Civil Engineering Elective (3)**
EES 326 Geologic Evolution of North America (3)
ECS 1 Principles of Economics (4)

**fifth year, second semester (15 credit hours)**
CE 270 Water Supply and Wastewater Management (4)
EES 134 Introduction to Optical Mineralogy and Crystallography (3)
EES 326 Geologic Evolution of North America (3)
ECO 1 Principles of Economics (4)

**summer (6 credit hours)**
EES 341 Field Geology (6)

**Classical Studies**

**Professor.** Charles Robert Phillips, III, Ph.D. (Brown).

**Associate professors.** Barbara Pavlock, Ph.D. (Cornell), head of program; David B. Small, Ph.D. (Cambridge).

The study of classics examines firstly the origins and growth of Greek and Roman culture in the Mediterranean area and secondly its impact on that area (and others) until the present. This study is by nature interdisciplinary: the study of language and literature, history, philosophy and religion, archaeology, economics and science all contribute to an appreciation of Greco-Roman civilization.

Students in either major or minor programs may concentrate in various combinations of these and other disciplines as they relate to ancient civilization. The diversity of professional interest in the program should encourage the student to follow her or his special interests while simultaneously gaining an overview of classical civilization.

Courses in ancient Greek and Latin lead to proficiency in language while introducing the student to major literary texts.
The Joseph A. Maurer Classics Prize is awarded yearly, at the discretion of the program, to the senior(s) who has demonstrated outstanding achievement in classics (ancient Greek or Latin) and/or classical civilization. Courses in classical civilization require no knowledge of the ancient languages; they offer introductions to various disciplines of classics with frequent reference to modern perspectives. Upper-level courses tend to be small, fostering closeness between faculty and students. Petitions are required for freshmen to take 100-level or higher courses and for sophomores to take 200-level or higher courses.

Major programs. Students may major either in classical civilization or classics. The classics major offers a comprehensive view of language and culture; it is possible to begin an ancient language at Lehigh and to complete the major program successfully. Depending on interests and preparation, the student should derive equal educational benefit from either major program. The program welcomes double majors and the educational perspectives to be derived from combining ancient and modern studies.

Classics as a major has stood the test of time, offering helpful preparation for careers in widely diverse fields in the professions, business, and public service. Lehigh classics majors have gone on to law school, the ministry, business school, with appropriate science courses to medical school, graduate work in classics, and to all kinds of entry-level employment.

Departmental Honors. A student may be recommended for program honors by vote of the program based on the student’s course work.

Minor program. The minor in classical civilization or classics consists of a minimum of 15 credit hours. Students may focus on any aspect of classical studies, either singly or in combination. The program can arrange individual courses of study.

Study abroad. Lehigh University is a cooperating institution of the Intercollegiate Center for Classical Studies at Rome and of the American School of Classical Studies at Athens. Lehigh students are eligible for tuition grants at Athens and Rome.

Major in Classical Civilization
This major allows the student to gain an overview of Greco-Roman culture through the literature, archaeology, and history along with basic language study. A minimum of 30 to 33 credit hours, depending upon previous preparation in language study, is required for this major.

Any four of the following:
Clss 52 (Engl 52) Classical Epic (3)
Clss 54 (Engl 54, Thtr 54) Greek Tragedy (3)
Clss 56 (Engl 56) The Ancient Novel (3)
Clss 58 (Engl 58, Thtr 58) Greek and Roman Comedy (3)
Clss 108 (Anth 108, Art 108, Arch 108) Greek Archaeology (3)
Clss 109 (Anth 109, Art 109, Arch 109) Roman Archaeology (3)

Any two courses in ancient history

Any two electives from the remaining classics offerings (Anth 178 may be included)

One course in either Latin or Greek on the intermediate level (or Lat/Grk 1, 2, 11, or 12, depending on previous background)

Major in Classics
This major allows the student to concentrate in ancient Greek, Latin or both. Specific programs for this major are worked out for each student with due consideration for the individual’s particular previous study of the language(s). Thus a student may begin ancient Greek or Latin at Lehigh and successfully complete a major in it. A minimum of 30 to 33 credit hours, depending upon previous language study, is required for this major.

Required major courses
Latin 1 and 2 or Greek 1 and 2, depending on prior preparation
Latin 11 and 12, or Greek 11 and 12, depending on prior preparation
three advanced courses in the major language minimum
any two ancient history courses
at least two electives from the remaining classics offerings

Courses in Classical Civilization (Clss)
Clss 21. (Hist 21) Greek History (3) fall
The development of civilization from neolithic times to the world empire of Alexander the Great. The social, economic, religious, philosophic, artistic and literary development of the ancient world; the origin of political institutions. Phillips (SS)

Clss 22. (Hist 22) Roman History (3) spring
Rome from its origins to A.D. 476. Political, social and religious developments. Transformation of the late Roman Empire to the early medieval period. Phillips (SS)

Clss 50. Mythology (3) fall
Introduction to the myth-making process, both ancient and modern; emphasis on Greek myth. (SS)

Clss 52. (Engl 52) Classical Epic (3)
Study of major epic poems from Greece and Rome. Works include Homer’s Iliad and Odyssey, Apollonius’ Argonautica, Vergil’s Aeneid, and Ovid’s Metamorphoses. Pavlock (HU)

Clss 54. (Engl 54, Thtr 54) Greek Tragedy (3)
Aspects of Greek theater and plays of Aeschylus, Sophocles, and Euripides in their social and intellectual contexts. Pavlock (HU)

Clss 56. (Engl 56) The Ancient Novel (3)
Examination of the origins of the novel in Greece and Rome. Includes the picaresque novel. Pavlock (HU)

Clss 58. (Engl 58, Thtr 58) Greek and Roman Comedy (3)
Study of comedy as a social form through plays of Aristophanes, Menander, Plautus, and Terence. Pavlock (HU)

Clss 108. Ancient Technology (3) spring
Technology and technique from the stone ages to the beginning of the industrial age; their effects on society. Attitudes to technology in ancient myth literature, philosophy, and religion. (SS)

Clss 112. (Anth 112) Doing Archaeology (3)
Principles of archaeological method and theory. Excavation and survey methods, artifact analysis, dating techniques, and cultural reconstruction. Course includes field project. Prerequisite: Anth 1 or department permission. Small (SS)

Early Christianity from its beginnings until the end of the second century. Coverage includes the Jewish and Hellenistic matrices of Christianity, traditions about the life of Jesus and his significance, and the variety of belief and practice of early Christians. Emphasis on encountering primary texts. Wright. (HU)

Clss 121. (Anth 121) Environment and Culture (3)
Impact of environment upon cultural variability and change. Comparative study of modern and past cultures and their environments as well as current theories of human/environmental interaction. Prerequisite: Anth 1 or department permission. Small (SS)
Clss 127. (Anth 127) Early Civilizations (3)
Introduction to early civilizations in the Near East, Mediterranean, Africa, Europe, and the New World. Similarities and differences in economics, politics, social organization, and religion. Prerequisite: Anth 1 or department permission. Small (SS)

Clss 131. (Phil 131) Ancient Philosophy (4) fall
Historical survey of selected texts and issues in the classical world, from the pre-Socratics through Aristotle, with emphasis on the origins of the western philosophical traditions in ethics, metaphysics, and epistemology. (HU)

Clss 132. (Phil 132) Hellenistic Philosophy (4)
Historical survey of selected texts and issues in Post-Aristotelian Greek and Roman philosophy from the fourth century B.C. to the third century A.D. Areas of focus may include epicureanism, stoicism, academic and pyrrhonian scepticism, and neoplatonism. (HU)

Clss 152. (Hist 152, WS 152) Women in Antiquity (4)
Interdisciplinary study of women in Greece and Rome. Literary, archaeological and historical evidence and approaches. Cross-cultural material. (SS)

Clss 161. (Hist 161) Roman Law (4)
Examination of Roman legal systems from the Twelve Tables to the Digest of Justinian. Emphasis on development of legal concepts and their historical context. Readings in primary sources; lectures; discussion. Phillips (SS)

Clss 174. (Anth 174, Art 174, Arch 174) Greek Archaeology (3)
Ancient Greek culture from the neolithic to hellenistic periods. Reconstructions of Greek social dynamics from study of artifacts. Small (SS)

Clss 176. (Anth 176, Art 176, Arch 176) Roman Archaeology (3)
Cultures of the Roman Empire. Reconstructions of social, political, and economic dynamics of the imperial system from the study of artifacts. Small (SS)

Clss 180. (Anth 180) Cultures of the Greeks and Romans (3)
Analysis of Greek and Roman cultures. Focus on kinship, political and economic organization, sexual practices, burial practices, gender construction, religions, art, literature, and warfare. Small (SS)

Clss 204. (Arch 204) Ancient City and Society (3)
Ancient theories of city and city planning; attitudes to life in the city; rise of urban civilization from Neolithic prototypes through the Near East, Egypt, Greece, Rome, and New World; insights applicable to current urban problems. Small

Clss 213. (Rel 213) Ancient Roman Religion (4)

Clss 231. (Phil 231) Figures/Themes in Ancient Philosophy (4)
This seminar course will involve in-depth focus upon a major ancient thinker (e.g. Plato, Aristotle, Sextus Empiricus, Plotinus, etc.) or the classical treatment of a particular theme (e.g. “human nature,” “the good life,” ethical or political theory, etc.). Content varies. May be repeated more than once for credit. (HU)

Clss 251. (Rel 251) Classical Mythology (3)
Myth, religion, and ritual in ancient Greece and Rome. Emphasis on primary sources; introduction to ancient and modern theories of religion. Cross-cultural material. (SS)

Clss 281. Readings (3) fall
Advanced study of a historical period or theme. Emphasis on primary sources. Prerequisites: Clss 21 or 22 and consent of the program head. (ND)

Clss 282. Readings (3) spring
Advanced study of a historical period or theme. Emphasis on primary sources. Prerequisites: Clss 21 or 22 and consent of the program head. (ND)

Clss 312. (Hist 312) Decline and Fall of the Roman Empire (3-4)
Political, social, and economic history of the Roman Empire, A.D. 117-180. Romanization of the provinces, diffusion of Christianity, and special attention to transformation to medieval period. Includes readings in translation of primary sources. Phillips (SS)

Clss 313. (Hist 313) Golden Age of Greek Democracy (3-4)
Greek history of the seventh through fifth centuries B.C. Emphasis on the contrasting political and social systems of Athens and Sparta with consideration of related economic and military history. Attention to art, gender, literature, religion. Discussion and lectures; papers. Phillips (SS)

Clss 314. (Hist 314) Age of Caesar and Christ (3-4) spring
Roman history of the first century A.D. political, cultural, and socio-economic changes; special attention to the evolution of absolute power. Lectures, discussions, papers. Phillips (SS)

Clss 345. (Anth 345) Evolution of the State (3)
Theories of state formation. Comparison of evolutionary trajectories of early states in the Near East, Mediterranean, and the New World. Prerequisite: Anth 1 or department permission. Small (SS)

Courses in Ancient Greek

Grk 1. Elementary Ancient Greek I (3) fall
Fundamentals of the Greek language. Readings in the easier authors. Staff (HU)

Grk 2. Elementary Ancient Greek II (3) spring
Continued work in Greek vocabulary, forms, and syntax. Selected readings in Greek. Prerequisite: Grk 1. Staff (HU)

Grk 11. Intermediate Ancient Greek (3) fall
Readings in Herodotus, Homer, or Xenophon. Grammar review. Prerequisite: Grk 1 and 2, or one year of entrance Greek, or consent of the program head. (HU)

Grk 12. Intermediate Ancient Greek (3) spring
Plato: Euthyphro, Apology and Crito, or other dialogues. Prerequisite: Grk 11. (HU)

Grk 111. Greek Drama (3) fall, alternate years
Representative plays of Sophocles, Euripides and Aristophanes. Literary study of the drama. Prerequisite: Grk 12. (HU)

Grk 112. Greek Drama (3) spring, alternate years
Continuation of Grk 111. Prerequisite: Grk 12. (HU)

Grk 113. Greek Historians (3) fall, alternate years
Selections from Herodotus, Thucydides or Xenophon. Study of Greek historiography. Prerequisite: Grk 12. (HU)

Grk 271. Readings (3) fall
Intensive readings in one author or in a selected genre. Prerequisites: six credit hours at the 100 level and consent of the program head. (HU)
Cognitive science is the interdisciplinary study of how humans think and how machines think. How can our understanding of the way humans think improve the performance of machines that are meant to behave intelligently? How can our understanding of the ways to make machines behave intelligently improve our understanding of the way humans think? The disciplines most commonly involved in cognitive science studies are psychology, computer science, philosophy, linguistics, neuroscience, and anthropology.

The College of Arts and Sciences offers an undergraduate major and minor in cognitive science, as well as a graduate minor. Because of its broad interdisciplinary character, a cognitive science major prepares a student for a wide variety of careers or graduate study programs. The courses required for the major also readily lend themselves to a double major for those students in the humanities, natural sciences, social sciences, or computer science who have overlapping interests in cognitive science.

The B.A. with a major in cognitive science requires a minimum of 13 courses: 11 within the major itself and two in collateral areas. All majors are required to take Cognitive Science 7, an introduction to cognitive science. The remainder of the major is built around a core of four introductory courses, one from each of four disciplines central to cognitive science: cognitive psychology, artificial intelligence, philosophy, and linguistics. In addition, majors must complete five elective courses, five in three topical areas related to cognitive science (with no more than two in one area). The final integration of coursework occurs in the required senior seminar, CogS 301, in which students focus on a topic of their choice from a branch of cognitive science.

The collateral course requirements are Math 9, Introduction to Finite Mathematics (Fall) or Math 21, Calculus I, and CSc 11, Introduction to Computing. Students who take CSc 261 to satisfy the major electives requirement should choose Math 21 (a prerequisite of CSc 261) rather than Math 9. Additional coursework in mathematics is strongly recommended, as are: Psychology I, Biology 21 and 22, and Anthropology 12.

**Required Introductory Course**
CogS 7 Introduction to Cognitive Science (3 hours, Spring)

**Collateral Requirements**
Math 9 Introduction to Finite Mathematics or Math 21 Calculus I
CSc 11 Introduction to Computing

**Disciplinary Core Courses**
CSc 327 Artificial Intelligence Theory and Applications
Phi 250 The Minds of Robots, and Other People
Psyc 117 Cognitive Psychology
CogS 140 Introduction to Linguistics

**Major Electives**
After completing the introductory sequence and the four core courses, students must complete a minimum of five courses from three of the following groups with no more than two courses from any one group.

**Artificial Intelligence and Expert Systems:**
CSc 17 Structured Programming and Data Structures
CSc 262 Programming Languages
CSc 365 Natural Language Understanding
CSc 368 Artificial Intelligence

Students who qualify may take:
CSc 413 Robotics and Intelligent Machines, or
CSc 414 Expert Systems
Formal Models:
- Phil 114 Foundations of Logic
- Phil 214 Logical Theory
- CSc 261 Discrete Structures
- CSc 318 Automata and Formal Grammars

Philosophy:
- Phil 139 Contemporary Philosophy
- Phil 220 Knowledge and Justification
- Phil 260 Philosophy of Language

Cognitive Psychology:
- Psy 307 Seminar in Cognition
- Psy 320 Psycholinguistics
- Psy 351 Cognitive Development in Childhood

Sociocultural Influences on Cognition:
- SPsy 135 Human Communication
- SPsy 314 Attitudes, Attributes, and Actions
- Anth 376 Culture and the Individual

Neuroscience:
- Psy 176 Mind and Brain
- Psy 177 Introduction to Physiological Psychology
- Psy 373 Sensation and Perception
- Psy 375 Neuroanatomy of Behavior

Senior Seminar (3 hours)
After completing the sophomore introductory sequence and the four core courses, students pursue their own interests in their selections of major electives. The required senior seminar brings classmates together so that they can teach each other what they have learned in their respective concentrations. This integrates the material in the program and provides students the opportunity to undertake independent projects.

Recommended Timing of Courses
Freshman
- Sophomore: CogS 7 (spring), 2 Core Courses
- Junior: Csc 11, Math 9

Graduate Minor in Cognitive Science
The graduate minor or concentration in cognitive science is available to graduate students (primarily doctoral) majoring in psychology or computer science. It gives students an opportunity to develop expertise in the interdisciplinary study of information processing by humans as well as intelligent machines. Graduate students investigating mental processes such as language processing, reading, perception and action, planning, problem-solving, learning, category formation, or applications such as artificial intelligence or educational technology are encouraged to participate, with the approval of an advisor in their major program, by contacting the director of the Cognitive Science Supervisory Committee. On completion of the program, the director of the cognitive science program will issue a letter to the student certifying that he or she has met the requirements of the minor.

CogS 161 Supervised Research (2-4) (ND)
CogS 301 Senior Seminar in Cognitive Science (3) spring
Integration of the material from cognitive science via topics chosen by the students. (ND)
CogS 361 Independent Research (2-4) (ND)
CogS 399 Thesis (2-4) (ND)


CogS 423 (Psyc 423). Foundations of Cognitive Science. Survey of fundamental theory and methodologies from artificial intelligence, linguistics, cognitive psychology, philosophy, and neuroscience, as well as salient research problems such as knowledge acquisition and representation, natural language processing, skill acquisition, perception and action, and the philosophical question of intentionality.

Computer Science:
- CSc 413 Robotics and Intelligent Machines
- CSc 414 Expert Systems
- CSc 416 Advanced Issues in Knowledge-based Systems
- CSc 463 Seminar in Natural Language Processing
- CSc 465 Advanced Issues in Natural Language Processing
- CSc 327 Artificial Intelligence Theory and Applications
- CSc 368 Artificial Intelligence Programming

Psychology:
- Psyc 403 Cognitive Psychology
- Psyc 405 Developmental Psychology
- Psyc 448 Seminar in Psychology of Language or
- Psyc 320 Psycholinguistics.
- Psyc 476 Seminar in Cognition
- Psyc 480 Seminar in Cognitive Development
- Psyc 478 (CogS 478): Ontological Psychology

Education:
- Educ 430 Advanced Topics in Reading
- Edt 405 Hypermedia Theory and Application.
Phil 250 The Minds of Robots, and Other People

Anthr 376 Culture and the Individual

IE 415 Introduction to Neural Networks

Roy Eckardt College Scholar Program

Director. Ian Duffy, professor of history.
Advisory Council. Mark Bickhard, professor of psychology; Robin Dillon, professor of philosophy; Beall Fowler, professor of physics; Edward Gallagher, professor of English; Lucy Gans, professor of art and architecture; Norman Girardot, professor of religion studies; Charles Kraihanzel, professor of chemistry.

For program requirements, see College Scholar Program, section III.

389. Honors Project for College Scholars (1-8)
Opportunity for college scholars to pursue an extended project for senior honors. May be repeated for credit up to a maximum of 12 credit hours. Transcript will identify department in which project was completed. Prerequisite: consent of department chairperson.

281-284. College Scholar Seminar (3)
Seminars for college scholars. May be repeated for credit. Prerequisite: consent of program director.

Communication

See listings under Minor Programs in the College of Arts and Sciences and under Journalism and Communication.

Computer Engineering

See listings under Electrical Engineering and Computer Science.

Computer Science

See listings under Electrical Engineering and Computer Science.

Cooperative Undergraduate Education

The College of Engineering and Applied Science offers opportunities to students for cooperative work assignments with industrial or business firms and government agencies. In all cases, cooperative work assignments are optional on the part of the student and there is no obligation for the student to accept permanent employment nor for the cooperating organization to offer permanent employment.

When on a cooperative assignment, the student must register for course work during the summer prior to the first work period and complete all required university procedures, Cooperative Undergraduate Education, to maintain continuous full-time student status. The fee for this course is established by the university treasurer. Participation in a cooperative education program does not relieve the student from any regular requirement for the academic curriculum in which he or she is enrolled.

200. Cooperative Undergraduate Education (3-6)
Supervised cooperative work assignment to obtain practical experience. Prerequisite: consent of the college dean.

Counseling

See listings under Education.

Earth and Environmental Sciences

Professors. Peter K. Zeitler, Ph.D. (Dartmouth), chair; Bobb Carson, Ph.D. (Washington), dean of the College of Arts and Sciences; Edward B. Evenson, Ph.D. (Michigan); Kenneth P. Kodama, Ph.D. (Stanford); Paul B. Myers, Jr., Ph.D. (Lehigh); Craig E. Williamson, Ph.D. (Dartmouth).

Associate professors. David J. Anastasio, Ph.D. (Johns Hopkins); Gray E. Bebout, Ph.D. (U.C., Los Angeles); Bruce R. Hargreaves, Ph.D. (U.C., Berkeley); Anne S. Melzer, Ph.D. (Rice); Donald P. Morris, Ph.D. (Colorado). Carl O. Moses, Ph.D. (Virginia).

Visiting assistant professor. Eugene S. Ilion, Ph.D. (Johns Hopkins).

The Department of Earth and Environmental Sciences (EES) offers courses in ecology, environmental science, and geoscience and provides undergraduate and graduate programs leading to B.A. B.S. M.S. and Ph.D. degrees. These broad fields entail the study of complex systems consisting of air, life, rocks, and water. Those systems have existed, interacted, and coevolved over billions of years, and although humans are relative newcomers, we are driven to acquire knowledge and understanding of such systems because we depend on them for sustaining resources and because we are curious. Progress in scientific understanding often requires the study of well-defined 'model' systems or topically constrained subjects, but we also aspire to an integrated understanding of systems and the processes by which they interact.

The department's undergraduate major programs combine course and laboratory work, fieldwork, and experiential learning to convey concepts, develop analytical skills, and promote critical thinking. The programs are designed to ensure a firm foundation in mathematics, communication skills, and the traditional sciences (chemistry, physics, geology, and biology) and to provide a breadth of understanding of earth and environmental systems and processes. Academic advising in EES requires each student to articulate one's academic interests and aspirations and to take an active role in designing one's individual course of study within program guidelines. The B.A. program allows more flexibility in course selection, which may be used to pursue a minor or a second major. The B.S. program requires more math and collateral sciences and more focus within EES. In particular, the BS program requires a student to choose a concentration in ecology, environmental science, or geoscience. Each concentration provides specific requirements and recommendations to meet the needs of its students. B.A. students may choose to follow one of the concentrations or to sample more broadly from the EES curriculum. During the senior year, all EES majors participate in one of the department's senior seminar courses.
Many EES courses include field trips that complement course instruction and provide students with opportunities to make measurements in the field, but the EES degree also contains a specific field experience requirement that goes beyond course-related field trips. In meeting the field experience requirement, EES majors must commit time and effort to collecting samples or data in the field. The purpose of this requirement is to give all EES students an opportunity to work in and to learn from the ultimate laboratory: the real world. The field experience requirement can be satisfied through appropriate field courses (such as EES 341 and 384) or through participation in approved research, jobs, or internships (with EES faculty or in non-academic settings like corporations or government agencies). Participation in research is encouraged, and course credit for research projects can be easily arranged (see EES 293 and 393). A department honors program is available for qualified students who conduct original research with a faculty mentor and write a senior thesis.

An undergraduate degree in earth and environmental sciences prepares a student for graduate study in ecology, environmental science, or geoscience (see the description of EES graduate programs and courses below). Depending on one's interests and choice of electives, EES majors may be prepared for graduate study in other fields of science or in education, law, medicine, business, or policy studies. Employment opportunities exist in a number of fields, including environmental or geotechnical consulting, manufacturing, natural resources development, conservation, finance, law, policy, education, and advocacy.

A minor in earth and environmental sciences is available for students who wish to combine an interest in environmental science with technical or non-technical majors, such as engineering, economics, government, journalism, international relations, and others.

Students interested in an EES major or minor program can obtain more information through the department office or on the world-wide web (www.ees.lehigh.edu).

**Tier structure of courses in the EES Department**

EES courses are organized in tiers, which do not necessarily correspond to the course-numbering scheme, based on their role in the EES curriculum and their reliance on prerequisites.

- **Tier I**: Introductory Sequence. Two courses, EES 21 and 31; no prerequisites; required for EES majors
- **Tier 2**: Intermediate EES courses; may have prerequisites (Tier I, math/collateral sciences)
- **Tier 3**: Advanced EES courses; may have prerequisites (Tier I, Tier 2, math/collateral sciences)

Courses designated for Tier 2 and Tier 3 are listed in the BS program description.

**EES Major - Required of all majors.**

- **Tier I**: Introductory Sequence. Two courses, EES 21 and 31, combine to form an introduction to the major. Both courses are required of all majors and are prerequisites for all other EES courses.
- **Tier 2 and Tier 3 courses (at least 4 courses for at least 16 credits)**; one of these courses must be a designated EES senior seminar listed below.

   - EES 101. A student who declares the EES major after taking EES 101 may substitute the credits from EES 101 for EES 21 in the major program. Declared majors should take EES 21 rather than EES 101. Students may not receive credit for both EES 101 and EES 21. (Note that EES 101 is a 3 credit course and that there is a minimum number of credits that must be earned for the EES major.)
   - EES 41. A student who takes EES 41 without having taken EES 21, 101, or 112 will receive eight credits for EES 41. (In the EES major program, four credits from EES 41 substitute for EES 21 and four substitute for EES 112.)

   - If a student takes EES 41 after taking EES 21, only four credits will be awarded for EES 41. In the EES major, these four credits substitute for EES 112. A total of eight credits is awarded for the EES 21 and 41 combination. If a student takes EES 41 after taking EES 101, only five credits will be awarded for EES 41. In the EES major, four credits substitute for EES 112 and one credit applies to the introductory sequence requirement. A total of eight credits is awarded for the EES 101 and 41 combination.
   - A student may not receive course credit for EES 21, EES 101, or EES 112 after taking EES 41. A student may not receive course credit for EES 41 after taking both EES 21 (or EES 101) and EES 112.

**Degree Requirements: B.A. in Earth and Environmental Sciences**

requires a minimum of 121 credits

- University and College Requirements (at least 26 credits):
  - Arts and Science 1 (1 credit)
  - College Seminar (3 credits)
  - English Composition (2 courses for 6 credits)
  - Distribution Requirements (at least 2 humanities courses for at least 8 credits and at least 2 social sciences courses for at least 8 credits)

- Math and Collateral Science Requirements for the B.A. in EES (at least 19 credits):
  - 2 semesters of calculus equivalent to Math 51 and 52 or Math 21 and 22 (7 to 8 credits)
  - 1 semester of chemistry equivalent to Chem 21/22 (5 credits)
  - 1 semester of physics equivalent to Phys 11/12 (5 credits)
  - 1 additional course (at least 3 credits) approved by the adviser

Be advised that many graduate programs in science and many employment opportunities require additional courses in math and collateral sciences. Furthermore, Math 23 is a prerequisite for Math 21, which in turn is a prerequisite for many other math courses. Talk with an advisor about career objectives and recommended math and collateral science skills.

**Junior Writing Requirement:** The ability to express oneself clearly in writing is a critical skill for success in any chosen career. It is also integral to the learning experience. Students are encouraged to take courses that help develop written skills. To help ensure this, the College of Arts and Sciences requires each student to complete at least one writing intensive course and receive certification from the instructor of that course. EES 201 (Seismology: the Earth and the Environment), EES 203: the Earth's Potential Fields, EES 213 (Sedimentology and Stratigraphy), EES 354 (Methods in Limnology and Microbial Ecology), and EES 355 (Ecological Field Methods) are designated as writing intensive and fulfill the junior writing requirement. Students may also fulfill this requirement by taking writing intensive courses in other departments.

**Required courses for the major (at least 44 credits):**

- Tier 1 introductory sequence (EES 21 and EES 31)
- Tier 2 courses (at least 5 courses for at least 20 credits); two of these courses must be selected from the following EES foundation courses:
  - EES 123 Structural Geology and Tectonics
  - EES 131 Introduction to Rocks and Minerals
  - EES 251 General Ecology
  - EES 282 Climate, Geosphere, and Biosphere

- Tier 3 courses (at least 4 courses for at least 16 credits); one of these courses must be a designated EES senior seminar listed below:
  - EES 303 Active Tectonics
  - EES 326 Geologic Evolution of North America
  - EES 351 Limnology
Students may also fulfill this requirement by taking writing intensive courses in the major. Many graduate programs will require calculus, linear methods, or numerical analysis. Many graduate programs will also require a full year each of chemistry and physics, and some may require more (e.g., organic chemistry). Students are advised that many graduate programs in their areas of interest, consult with their major adviser, or courses selected to fulfill the EES Tier 2 and Tier 3 requirements before enrolling in any course in the major beyond the student's second Tier 2 course.

Justification of course selection: Each student must prepare a written justification, subject to approval by the major adviser, of courses selected to fulfill the EES Tier 2 and Tier 3 requirements before enrolling in any course in the major beyond the student's second Tier 2 course.

Degree Requirements: B.S. in Earth and Environmental Sciences

requires a minimum of 121 credits

University and College Requirements (at least 26 credits):
• Arts and Science 1 (1 credit)
• College Seminars (3 credits)
• English Composition (2 courses for 6 credits)
• Distribution Requirements (at least 2 humanities courses for at least 8 credits and at least 2 social sciences courses for at least 8 credits)

Math and Collateral Science Requirements for the BS in EES (at least 26 credits)
• 2 semesters of calculus equivalent to Math 21 and 22 (or Math 51/52) (at least 7 credits)
• 1 semester of chemistry equivalent to Chem 21/22 (5 credits)
• 1 semester of physics equivalent to Physics 11/12 (5 credits)
• 3 additional courses approved by the adviser. One of these 3 courses (for at least 3 credits must be a math or statistics course).

Students are advised that many graduate programs in science and many employment opportunities require additional course in math and collateral sciences, as well as additional courses in the major. Many graduate programs will require calculus beyond Math 22, statistics, or other math courses like differential equations, linear methods, or numerical analysis. Many graduate programs will also require a full year each of chemistry and physics, and some may require more (e.g., organic chemistry). Students may need to use a free elective to acquire sufficient math and collateral science for certain programs. Students should obtain information about the requirements for graduate programs in their areas of interest, consult with their major adviser, and plan accordingly. Consult the concentration descriptions below for specific requirements and recommendations.

Junior Writing Requirement: The ability to express oneself clearly in writing is a critical skill for success in any chosen career. It is also integral to the learning experience. Students are encouraged to take courses that help develop written skills. To help ensure this, the College of Arts and Sciences requires each student to complete at least one writing intensive course and receive certification from the instructor of that course. EES 201 (Seismology: the Earth and the Environment), EES 203: the Earth's Potential Fields, EES 213 (Sedimentology and Stratigraphy), EES 354 (Methods in Limnology and Microbial Ecology), and EES 355 (Ecological Field Methods) are designated as writing intensive and fulfill the junior writing requirement. Students may also fulfill this requirement by taking writing intensive courses in other departments.

Required courses for the major (at least 47 credits)
• Tier 1 introductory sequence (EES 21 and EES 31)
• Tier 2 courses (at least 5 courses for at least 20 credits); two of these courses are the required foundation courses for the student's concentration
• Tier 3 courses (at least 4 courses for at least 16 credits); one of these courses must be a designated EES senior seminar course for the student's concentration.
• Additional course approved by the major adviser; 1 course selected from EES Tier 2 or Tier 3 or from courses at the 100 level or above in other math, science, or engineering departments (at least 3 credits)
• Free electives: courses chosen from anywhere in the University's curriculum; sufficient credits to bring the total to a minimum of 121
• Field experience: course, internship, or employment preapproved by the adviser to meet the EES field experience requirement. Course credit is not required to fulfill this requirement, but EES 41, 341, and 384 will satisfy this requirement.

Justification of course selection: The student must prepare a written justification, subject to approval by the major adviser, of courses selected to fulfill the EES Tier 2 and Tier 3 requirements before enrolling in any course in the major beyond the student's second Tier 2 course.

B.S. Concentration: The student must select a concentration in geology, environmental science, or geoscience and follow the required selection of Tier 2 and Tier 3 courses prescribed for that concentration. Note that certain concentrations have additional requirements or recommendations especially with respect to math and collateral sciences and field experiences. Refer to the pertinent concentration description below.

Concentration in Geoscience

Geoscience combines geology, geophysics, and geochemistry to understand the earth and the environment. EES 341 (Field Geology) is required for the geoscience concentration and satisfies the EES field experience requirement. The eight credits awarded for EES 341 are partitioned equally between the Tier 3 requirement and the BS requirement for an additional course at Tier 2 or Tier 3.

To concentrate in geoscience students take at least 5 Tier 2 courses (at least 20 credits; 2 foundation courses plus 3 others) and at least 4 Tier 3 courses (at least 16 credits; one of which must be a senior seminar course).

Students must take these Tier 2 foundation courses:
EES 123 Structural Geology and Tectonics (4)
EES 131 Introduction to Rocks and Minerals (4)

Choose: at least 3 additional Tier 2 courses to bring tier 2 total to at least 20 credits
EES 112 Geomorphology (4) (note possible substitution by EES 41)
EES 113 Paleontologic Evidence for Earth Evolution (4)
EES 201 Seismology, the Earth, and the Environment (4)
EES 203 Geophysical Field Methods: Gravity, Magnetics, Electrical Resistivity, and Well Logging (4)
EES 213 Sedimentation and Stratigraphy (4)
EES 221 Plate Tectonics: How it Works (2)
EES 228 Climate, Geosphere, and Biosphere (4)
EES 293 Supervised Internship (variable credit, 1-4)
EES 373 Environmental Thermodynamics (4)

Students must take EES 341 and choose at least 3 other courses, one of which must be a senior seminar course, designated with *, for a total of at least 16 tier 3 credits.
EES 309 Mineral Magnetism and Earth Processes (4)
EES 307 Case Histories in Engineering Geology (4)
Choose: at least 3 additional Tier 2 courses to bring tier 2 total to at least 20 credits

EES 112 Geomorphology (4) (note possible substitution by EES 41)
EES 113 Paleontological Evidence for Earth Evolution (4)
EES 123 Structural Geology and Tectonics (4)
EES 131 Introduction to Rocks and Minerals (4)
EES 151 Plants and Plant Communities (4)
EES 201 Seismology, the Earth, and the Environment (4)
EES 203 Geophysical Field Methods: Gravity, Magneitics, Electrical Resistivity, and Well Logging (4)
EES 213 Sedimentation and Stratigraphy (4)
EES 221 General Ecology (4)
EES 229 Supervised Internship (variable credit, 1-4)
EES 375 Environmental Thermodynamics (4)
EES 383 Environmental Instruments and Data (4)
CEE 143 Soil Mechanics (4)
CEE 223 Hydraulics for Earth and Environmental Scientists (4)

Choose: at least 4 Tier 3 courses, one of which must be a senior seminar designated by an *, for a total of at least 16 credits at tier 3
EES 303 Active Tectonics* (4)
EES 307 Case Histories in Engineering Geology (4)
EES 309 Mineral Magnetism and Earth Processes (4)
EES 316 Hydrogeology (4)
EES 341 Field Geology (8)
EES 351 Limnology* (4)
EES 353 Environmental Microbiology* (4)
EES 354 Methods in Limnology and Microbial Ecology (4)
EES 355 Ecological Field Methods (4)
EES 376 Geochemistry of Natural Waters* (4)
EES 384 Lake Ecosystems (4)
EES 393 Supervised Research (variable credit, 1-4)
CEE 320 Flood Hydrology and Hydraulics (3)
CEE 326 Engineering Groundwater Hydrology (3)

Minor in Earth and Environmental Sciences
The minor program in EES requires a minimum of 15 hours, which must include the EES Tier I sequence (EES 21 and 31) and at least two additional EES courses from Tier 2 or Tier 3 (see listings under the BS program description).

Combined B.A. or B.S. and M.S. Program in Earth and Environmental Sciences
The Department of Earth and Environmental Sciences offers a five-year combined B.A. or B.S. and M.S. program. The department offers M.S. degrees in geological science and environmental science (refer to the description of Graduate Programs in EES following the listing of undergraduate course descriptions). Students working toward the BA or B.S. degrees who are enrolled in this program complete the full requirements for both degrees and apply some 300- and 400-level course credit taken as an undergraduate towards the M.S. degree without additional undergraduate tuition cost. The program is designed for those students who (1) will have at least nine credits of appropriate M.S. course credits in excess of undergraduate requirements completed by the end of the senior year, including one EES graduate core course (EES 415, 426, or 484), (2) have completed a minimum of three credits of EES 393 (Supervised Research) as part of the baccalaureate program, and (3) have demonstrated superior academic achievement.

Application for admission to the program should be made no later than the beginning of the first semester of the senior year and must be approved by the department's Graduate Instruction Committee. The application must include (1) a current baccalaureate degree audit, (2) the proposed M.S. course program, and (3) a letter of recommendation from the proposed M.S. thesis adviser. Students enrolled in this program should make application for admission to full-time graduate status during the first semester of the senior year.
After receiving the bachelor's degree and becoming enrolled in the graduate program, students in the dual-degree program become eligible for financial aid, including appointment to a teaching or research assistantship or graduate fellowship. Admission to the program does not guarantee financial aid.

**Department Honors in Earth and Environmental Sciences**

Students in either the B.A. or B.S. degree programs may undertake a program that leads to graduation with department honors. To participate, the student must have a minimum overall cumulative GPA of 3.0, file a written request with the EES undergraduate instruction coordinator to receive honors no later than the beginning of the senior year (preferably during the junior year), and complete at least four credits of EES 393 (Supervised Research in Earth and Environmental Sciences). An advisory committee of two EES faculty plus the student's research supervisor must be constituted to supervise and guide the research and to approve the required honors thesis. For the thesis to qualify for department honors, the student must give an oral presentation of its results and conclusions at a department seminar before the last day of classes in the second semester of the senior year.

**Undergraduate Courses**

**EES 3. Global Environmental Change (4)**
Review of the environmental systems that carry out the exchange of energy and matter between the solid earth, the oceans, the atmosphere, and the biosphere. Examination of the global environmental change that has been a fact of life on Earth for several billion years, the role of humans in causing global environmental change, and the potential impact of such change on humans; debate over what course of actions is required to ensure the continued habitability of this planet. The course is intended for non-science majors wishing to learn more about the science behind current environmental issues, and fulfills a distribution requirement in science. Lectures, class discussions, debates, and group projects. Meltzer and Zeitler. (NS)

**EES 11. Environmental Geology (3)**
Analysis of the dynamic interaction of geologic processes and human activities. Catastrophic geologic processes (earthquakes, volcanoes, landslides), pollution of geologic systems, and engineering case studies. Evenson (NS)

**EES 21. Introduction to Planet Earth (4)**
Processes within the Earth and dynamic interactions among the solid earth, the atmosphere, and the hydrosphere. Lectures, laboratories, and field trips. Anastasio, Kodama (NS)

**EES 31. Introduction to Environmental/Organismal Biology (4)**
Introduction to the structure, function, and evolution of living systems, with emphasis at the levels of organism, population, community, and ecosystem. Lectures and laboratories. Hargreaves, Morris (NS)

**EES 41. Physical Geology and Geomorphology in the Rocky Mountains (8)**
Geology of Wyoming and Idaho. Six weeks of morning lectures and afternoon field exercises conducted in field settings in South Dakota, Wyoming, and Idaho during the summer session. See EES 341 description for location details. May substitute for either EES 21 or 101 and EES 112 (see EES 21 and 112 descriptions for content); see Introductory Sequence section of EES program description for restrictions on overlapping credit. Prerequisite: consent of Field Camp Director Evenson (students must apply through the Lehigh Field Camp Program). Evenson (NS)

**EES 90. College Seminar (3)**

**EES 93. Freshman Supervised Internship in Earth and Environmental Sciences (1-2)**
Experiential learning opportunities supervised by EES faculty, including fieldwork, data collection or analysis, literature review, and information management. A maximum of two credits is allowed. Prerequisite: consent of supervising faculty. (ND)

**EES 101. Geology for Engineers (3)**
A study of the materials that make up the earth, the physical, chemical, and environmental history that they relate, and the processes that act to change them. Designed primarily for upperclass science and engineering majors. Lectures and laboratory. Myers (NS)

**EES 112. Geomorphology (4)**
Systematic study of the origin, evolution, and distribution of the Earth's topographic features; land forms analyzed in terms of chemical and physical processes responsible for their development. Lectures and required 3-day field trip. Prerequisites: EES 11, 21, or 101. Evenson (NS)

**EES 113. Paleontologic Evidence for Earth Evolution: Life and Climate in the Rock Record (4)**
Physical and chemical formation of early Earth and its atmosphere; appearance of life; evolution of life forms as recorded in the sedimentary record. Environmental changes and responses to plate tectonic movements and extra-terrestrial factors. Lectures, seminars. Laboratory and field trips. Prerequisites: EES 21 or EES 101. Carson and Zeitler (NS)

**EES 119. ArcView GIS and Spatially Referenced Data (2)**
An introduction to the capabilities and uses of the ArcView Geographic Information System (GIS) to create, edit, display, query, and analyze geographically referenced data. Includes the applications of GIS to spatially referenced data of all types. Combined lecture/lab sessions. No prerequisites. (ND)

**EES 123. Structural Geology and Tectonics (4)**
Application of basic concepts of stress, strain, and material properties to the study of folds, faults, and rock fabrics. Plate tectonic processes and plate margin deformation. Introduction to map and field techniques. Lectures, laboratories, and two all-day field trips. Prerequisite: EES 21. Anastasio (NS)

**EES 131. Introduction to Rocks and Minerals (4)**
Hand-specimen identification of the major mineral groups and rock types. Atomic structure of minerals; relationship of mineral structure to chemical and physical properties. Placement of igneous, sedimentary, and metamorphic rocks into a plate tectonics context. Introduction to optical mineralogy and x-ray diffraction techniques. Lectures, laboratories, field trips. Prerequisite: EES 21 or EES 101 or EES 41 or consent of instructor. Bebout (NS)

**EES 151. (BioS 151) Plants and Plant Communities (4)**
Structure and function of plants and plant communities. Discussion of plant physiology and environmental factors controlling plant distribution; structural and physiological adaptations of plants to their environment; the role of the physical environment, competition, herbivory, and disturbance in structuring plant communities; the evolution of plants and communities. Prerequisite: EES 31. (NS)

**EES 201. Seismology, the Earth, and the Environment (4)**
An examination of how earthquakes and active source seismology are used to image subsurface structure and stratigraphy. Fundamentals of seismic wave propagation in the Earth. Study of earthquakes, reflection and refraction techniques both at crustal scale (kilometers) and in high-resolution (1 to 100 m) applications, and ground-penetrating radar. Practical
applications to both earth and environmental sciences. Field and laboratory projects. Prerequisites: EES Tier 1 sequence (EES 21 and 31), one semester each of calculus and physics. Meltzer (NS)

EES 203. Geophysical Field Methods: Gravity, Magnetics, Electrical Resistivity, and Well Logging (4)
Application of gravity, magnetic, electrical, paleomagnetic, and well-logging techniques to environmental and geological problems. Emphasis on practical experience in the field. Students will collect, analyze, and model data to solve geologic and environmental problem. Prerequisites: EES 21, one semester each of calculus and physics. Kodama (NS)

EES 213. Sedimentology and Stratigraphy (4)
Processes of sediment transport, deposition, and diageneis of clastic and non-clastic sediments; sedimentary textures and structures; lithostratigraphy and stratigraphic correlation using biologic, magnetic, seismic, and radiometric methods. Lectures and laboratories. Prerequisites: EES 113 or consent of department chair. Carson (NS)

EES 221. Plate Tectonics: How it Works (2)
Historical development of the plate tectonic model. Emphasis on how to do plate tectonics, i.e., how to calculate spreading rates, angular velocity vectors, finite rotations, relative Euler poles, total plate reconstruction poles and stage poles, global plate circuits, and absolute plate motion. Lectures and laboratories (seven weeks) Prerequisites: EES 123, one semester each of calculus. Kodama (NS)

EES 251. (BioS 252) General Ecology (4)
Basic principles and applications of ecological interrelationships. Examination of ecological phenomena at the individual, population, community, and ecosystem levels. Impact of human activities on global ecosystems. Prerequisite: EES 31. Williamson (NS)

EES 282. Climate, Geosphere, and Biosphere (4)
Interactions of Earth-surface fluids (air and water) with the organic and inorganic components of the Earth system, as expressed through climate, landscape evolution, biogeography, and biogeochemical cycles. Modern processes and historical perspective on environmental change. Lectures, discussion, and laboratory. Prerequisites: one semester each of calculus, chemistry, and physics; EES Tier 1 sequence (EES 21 and 31). Moses (NS)

EES 293. Supervised Internship in Earth and Environmental Sciences (1-4)
Experiential learning opportunities supervised by EES faculty, including data collection or analysis, literature review, information management. A maximum of four credits of EES 293 and no more than eight credits combined from EES 293 and 393 may be applied to EES major (additional credits apply to free electives). Prerequisite: consent of supervising faculty.

Advanced Undergraduates and Graduate Students

EES 303. Active Tectonics (4)
An integrative look at how internal and external processes shape the Earth. Review of the observations and evidence leading to a unified understanding of how physical processes in the Earth's interior shape the external surface on which we roam. Topics include issues in continental dynamics such as mountain building, basin formation, and the interplay between tectonics and climate. Lectures, problem sets, modeling exercises, student projects and presentations. Prerequisites: EES Tier 1 sequence (EES 21 and 31), at least five courses in EES Tier 2 or 3. Meltzer (NS)

EES 307. Case Histories in Engineering Geology (4)
Methods of geological investigation at engineering sites. Assessing suitability of a proposed site, acquiring geological information for proper engineering design, and recognizing potential geotechnical problems during and after construction. Prerequisite: Junior standing in the Department of Earth and Environmental Sciences or consent of instructor. Myers (NS)

EES 309. Mineral Magnetism and Earth Processes (4)
The use of earth material magnetic properties to study environmental and geologic systems and processes. Techniques of magnetic measurements, characteristics of the Earth's magnetic field, and mineral magnetism. Prerequisites: EES 21, Phys 11/12. Kodama (NS)

EES 316. Hydrogeology (4)
Interrelationships of geologic materials and processes with water; entry, storage, interaction, and flow of water through permeable earth materials; evaluation, development, and management of ground-water resources. Lectures and recitation/laboratory. Prerequisites: EES 21 or EES 101. Myers (NS)

EES 319. Environmental Applications of Geographic Information Systems (4)
Use of spatial database system (ARC/INFO) in the storage and manipulation of data necessary for the evaluation and management of ground-water systems. Prerequisite: EES 316 or equivalent. Myers (NS)

EES 326. Geologic Evolution of North America (4)
A senior seminar on the lithologic, tectonic, and morphologic evolution of North America; developed within the framework of the plate tectonic theory. Prerequisites: EES Tier 1 sequence (EES 21 and 31), at least five courses in EES Tier 2 or 3. Anastasio and Myers (NS)

EES 334. Petrology of the Crust and Mantle (4)
Crust and mantle evolution as recorded by the mineralogy, texture, and geochemistry of igneous, sedimentary, and metamorphic rock. Origin of the three rock types in various plate tectonic settings. Mass and energy transfer among the crust, mantle, hydrosphere, biosphere, and atmosphere through time. Petrographic study of selected rock suites and introduction to other modern analytical techniques used in petrology/geochemistry. Lectures, laboratories, field trips. Prerequisite: EES 131 or consent of instructor. Bebout (NS)

EES 337. (Chem 337, Mat 333) Crystallography and Diffraction (3)
Introduction to crystal symmetry, point groups, and space groups. Emphasis on materials characterization by x-ray diffraction and electron diffraction. Specific topics include crystallographic notation, stereographic projections, orientation of single crystal, textures, phase identification, quantitative analysis, stress measurement, electron diffraction, ring and spot patterns, convergent beam electron diffraction (CBED), and space group determination. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Lectures and laboratory work. Prerequisite: Mat 203 or EES 131 or senior standing in chemistry. Lyman, Chan. (NS)

EES 338. (Mat 334, Chem 334) Electron Microscopy and Microanalysis (4)
Fundamentals and experimental methods in electron optical techniques including scanning electron microscopy (SEM), conventional transmission (TEM), and scanning transmission (STEM) electron microscopy. Specific topics covered will include electron optics, electron beam interactions with solids, electron diffraction and chemical microanalysis. Applications to the study of the structure of materials are given. Prerequisite: consent of the department chair. Williams, Lyman. (NS)
EES 341. Field Geology (8) summer
Field study and geologic mapping of sedimentary, igneous, metamorphic, and glacial deposits in the Rocky Mountains of northwestern Wyoming and southeastern Idaho. Additional study in the Badlands and Black Hills of South Dakota, the Grand Tetons, Yellowstone Park, Craters of the Moon Park, and other areas in the Rocky Mountain region. Six weeks in the field; summer session. Prerequisite: consent of Field Camp Director Evenson (students must apply through the Lehigh Field Camp Program); major in EES, EES 21 and 131 (EES 112, 113, 123 recommended). Evenson, Myers, Anastasio, Bebout (NS)

EES 351. (BioS 351) Limnology (4)
Physical, chemical, and biological aspects of freshwater environments, including cyclic and seasonal changes. Major groups of organisms and their interactions. Prerequisite: EES 31. Williamson (NS)

EES 353. (BioS 354) Environmental Microbiology (4)
The role of microorganisms in the environment. Topics include: survey of microbial classification, structure, and metabolism; study of microbes at population, community, and ecosystem levels of organization; the role of microbes in biogeochemical cycles; application of microbes to bioremediation and resource recovery problems. Fall (alternate (even) years). Prerequisite: EES 31 and EES 251, or consent of instructor. Morris (NS)

EES 354. Methods in Limnology and Microbial Ecology (4)
Investigation of topics in limnology and microbial ecology using an integrative approach that encompasses data acquisition, data analysis, and communication of results. Chief issues: (1) theory and application of standard techniques in limnology and microbial ecology, (2) quantitative analysis or modeling of existing or acquired data sets, and (3) data presentation and scientific report writing. Fulfills college writing intensive course requirement. Students must attend several Saturday field trips during the semester. Lectures and laboratories. Pre- or corequisite: EES 351 or EES 353. Offered every spring. Morris (NS)

EES 355. (BioS 355) Ecological Field Methods (4)
An intensive field course designed to familiarize students with field sampling techniques, data analysis, and report writing related to field-based ecological research. Includes description and mapping of plant and animal communities, population dynamics, and plant-animal interactions in both terrestrial and aquatic habitats. Weekend field trip to Lacawac Sanctuary. Pre- or corequisite: EES 251. Williamson (NS)

EES 361. (BioS 362) Environmental Animal Physiology (4)
Response of animals to their environment, including adaptations for stressful habitats and homeostatic mechanisms. Levels of response and adaptation range from cells and tissues to organ systems and whole organisms. Lecture and recitation. Prerequisites: EES 31 and BioS 31. (NS)

EES 373. Environmental Thermodynamics (4)
Development of fundamental macroscopic thermodynamic principles with applications to geochemical, atmospheric, and aquatic systems. Topics include the laws of thermodynamics, thermodynamic relationships, phase transitions, aerologic diagrams, chemical equilibria, chemical potential diagrams, and stability in different systems. Lectures and recitation. Prerequisites: two semesters of calculus, one semester each of chemistry and physics; EES Tier 1 sequence. Moses (NS)

EES 376. Geochemistry of Natural Waters (4)
Introduction to aqueous geochemistry. Applications of thermodynamics, mass balance, systems science, and kinetics to understanding mineral-water interactions in natural aquatic systems on a variety of spatial and temporal scales. Laboratories emphasize analytical and computer methods. Lectures, discussion, student presentations, and recitation/laboratory. Prerequisites: two semesters of calculus, one semester each of chemistry and physics; EES Tier 1 sequence; at least two courses from EES Tier 2 (EES 131 recommended); or consent of instructor. Moses (NS)

EES 383. Environmental Instruments and Data (4)
Obtaining quality data from sensors and instruments requires an understanding of their properties including inherent limitations, sensitivity, and calibration. Large data sets generated by electronic instruments require careful management to retain full information content. Activities include sensor and instrument use, team projects, multimedia presentations, and extensive use of relational databases. 3 lecture/demonstration periods per week and one laboratory period. A weekend trip to calibrate research instruments and deploy team projects. Prerequisites: EES 21, EES 31, or consent of instructor. (NS)

EES 384. Lake Ecosystems (4)
Advanced concepts and methods in lake ecosystem ecology. The course provides a theoretical framework but emphasizes hands-on laboratory and field techniques for measurement of physical, chemical, and biological properties of aquatic ecosystems. This three week residential field course is offered at the Lacawac Sanctuary field station in the Pocono Mountains of Pennsylvania. The course typically begins during the last week of May. Prerequisite: EES 31 and EES 251 or consent of instructors. Limited enrollment. Hargreaves, Morris, and others. (NS)

EES 393. Supervised Research in Earth and Environmental Sciences (1-4)
Research opportunities supervised by EES faculty, including exposure to problem definition, selection of research approach, and communication of results. A maximum of four credits of EES 293 and no more than eight credits combined from EES 293 and 393 may be applied to EES major (additional credits apply to free electives). Prerequisite: consent of supervising faculty.

For Graduate Students
The Department of Earth and Environmental Sciences offers graduate degree programs leading to the M.S. or Ph.D. in geological sciences and in environmental science. Research is an important and integral part of the graduate programs; a student selects a research problem through consultation with one's adviser. Graduate students make annual presentations of their research to the department. M.S. students complete 30 credits of coursework and present a written thesis reporting their investigation of a specific problem. Candidates for the Ph.D. must pass a qualifying examination administered by an examination committee prior to the start of an individual student's second semester and the general examination, which includes the public oral defense of the written dissertation proposal, prior to the end of the student's third semester. Ph.D. candidates also defend their written dissertation at a public oral presentation. All graduate students work with an adviser who chairs the individual student's supervisory committee. In addition, each graduate student must take two of the department's three graduate core courses (EES 415, 426, and 484). For details beyond the following summary, please contact the department.

Program in Geological Sciences. The department's geological sciences program emphasizes studies of the Earth's crust in both tectonic and surficial regimes. Graduate research in the geological sciences program is oriented toward geological processes in the general areas of structural geology, metamorphic petrology, isotopic geochemistry, sedimentation, glacial and Quaternary geology, geomorphology, paleomagnetism, reflection seismology, aqueous geochemistry,
hydrogeology, and geochronology. Aside from the core-course requirement, course selection is determined by the student in consultation with the supervisory committee.

**Program in Environmental Science.** The department's environmental science program stresses the interaction of biotic and abiotic components as the basis for understanding natural environmental systems. Process- and system-oriented graduate research opportunities in environmental science include sedimentation and Quaternary geology, environmental physiology, paleomagnetism and paleoclimatology, environmental magnetism, microbial ecology, aquatic geochemistry, hydrogeology, and plankton ecology. Three course programs are available, providing concentrations of environmental biology or surficial processes or providing more general training in environmental science. In addition to completing the department's core course requirement, students opting for a concentration must complete three of the designated courses in either aquatic ecosystems or surficial processes and one designated course in the other category, while students seeking general training in environmental science take two courses from each category. All students in the environmental science program must take a course in quantitative methods. M.S. theses are defended in a public oral presentation.

Special departmental research facilities of interest include: Philips APD-3600 automated X-ray powder diffractometer; Philips AXS automated X-ray fluorescence spectrometer, Debye-Scherrer X-ray powder camera; complete petrographic and incident-light microscopy facilities; hydrothermal apparatus for experimental mineralogy; a sediment-core laboratory with a computer-assisted Multi-Sensor Core Logger measuring sonic velocity, gamma-ray attenuation (bulk density), and magnetic susceptibility, a cold storage room, and a transportable Mackereth corer; floating plankton laboratory; complete laboratory for noble-gas and fission-track geochronology, including a low-blank, double vacuum resistance furnace and a VG isotopes model 3600 mass spectrometer; Finnigan MAT model 252 isotope ratio mass spectrometer and high-vacuum extraction lines for O, H, C, S, and N isotope analyses; paleomagnetism laboratory with a Molspin spinner magnetometer, a 2-Axis CTF Cryogenic Rock Magnetometer, a Schonstedt tumbling AF demagnetizer, and a Schonstedt thermal demagnetizer; reflection seismology laboratory with Apollo computer workstation for seismic processing and Bison DIFP multi-channel seismograph; sedimentation laboratory equipped with Particle Data computer-based particle-size analyzer and rapid sediment analyzer; field geophysical equipment including Bison shallow refraction seismic unit and Bison shallow resistivity apparatus, master Wordon gravimeter, Geometrics portable proton precession magnetometer; Keck borehole logging equipment including caliper, natural gamma, resistivity, and self-potential probes; downhole geochemical sampling equipment; Waters computer-assisted ion chromatograph; ARL 34000 inductively-coupled plasma atomic emission spectrometer (ICP/AES); NETZSCH DTA/TGA analyzer; Sun and IBM workstations which support CAD, mapping/contouring software, and ARC/INFO geographic information system; standard equipment for field mapping.

Three wells are also located on campus as an in situ groundwater laboratory. Students perform a variety of pump tests, geochemical sampling, and down-hole geophysical determinations at this facility.

The following major analytical facilities are available on campus to students and staff of the department: fully automated JEOL 733 electron microprobe, Philips 300 electron microscope completely equipped for transmission and diffraction, ETEC scanning microscope completely equipped for quantitative X-ray microanalysis and electron energy-loss spectroscopy, JEOL 6300F field-emission digital SEM with backscattered electron detector and image analysis, SCIENTA ESCA-300 x-ray photoelectron spectrophotometer; and Perkin Elmer double-beam infrared spectrophotometer.

Equipment to conduct environmental biology research is also available in the department. This includes, but is not limited to, computers, microscopes, environmental chambers, centrifuges, sampling nets, current meters, incubators, and autoclaves. A remotely operated vehicle (ROV) fitted with a video camera can be used to monitor plankton behavior and dynamics in an aqueous environment. The department also has the Aquatic Ecosystems Program (AEP), an interactive research and educational program, to study lake systems through multidisciplinary research and to provide training for undergraduate and graduate students. The program is centered at the Lacawac Sanctuary in the Pocono Mountains and focuses on three 'core' lakes that serve as model systems for experimental and comparative studies on aquatic communities and ecosystems. For more information about the AEP, please contact Prof. Morris (610-758-3660).

**EES 405. Paleo- and Environmental Magnetism (3)**
Topics in paleomagnetism and environmental magnetism. Class will design and conduct a research project, read the relevant literature and write a research paper. May be repeated for credit. Prerequisite: EES 309 or consent of course instructor. Kodama [spring even years]

**EES 407. Seismology (3)**
Seminar on advanced topics in seismology, review of classic and current literature. Topics include but are not limited to: wave propagation in ideal media and earth materials, seismic imaging of complex structures, tomography, modeling, and high-resolution seismic imaging. May be repeated for credit. Prerequisite: an introductory geophysics course. Melzer

**EES 414. Glacial and Quaternary Geology (3)**
Study of the origin, distribution, and movement of present and past glaciers. Special emphasis on glacial land forms and deposits, Quaternary stratigraphy and dating techniques, periglacial phenomena, and Pleistocene environments. Lectures and required field trips. Prerequisite: Consent of instructor. Carson and Moses

**EES 415. Paleoclimatology (3)**
Principles of physical climatology and the methods of reconstructing past climatic variation from a variety of records including stable isotopes. Emphasis is on the Quaternary. Issues related to linking climate variation to tectonic processes, chemical composition of the atmosphere and biogeochemical cycles, ocean-atmosphere interactions, and variations in the parameters of Earth's orbit. Prerequisite: graduate standing in EES. Carson and Moses

**EES 418. Advanced Glacial and Quaternary Geology (3)**
Lectures and seminars on selected contemporary topics. Topics include glaciology, ice cores, modern and ancient glacial environments and deposits. Required field trips. May be repeated for credit. Prerequisite: EES 414 or consent of course instructor. Evenson [fall odd years]

**EES 426. Tectonic Processes (3)**
Current models of tectonic processes in intraplate settings and at plate boundaries. Critical evaluations by the class of the geological, geochemical and geophysical data sets which gave rise to these models. Prerequisites: graduate standing in EES, or consent of department chairperson. Staff

**EES 427. Orogenic Belts (3)**
Geometry, kinematics, and mechanics of compressional orogenic belts. Course will emphasize deformational, depositional, and metamorphic processes in forearc and backarc regions. Lectures, seminars, and field trips. Prerequisites: EES 123, EES 131, and EES 213 or equivalents. Anastasio [fall even years].
EES 428. Stress and Strain in Rocks (3)
Theory of continuum mechanics and application to analytical methods of geological strain analysis; rock material properties and micro-mechanisms of rock deformation; tectonic fabric development; kinematic analysis. Lectures and laboratories. Prerequisite: EES 123 or equivalent. Anastasio

EES 429. Methods and Applications of Geochronology (3)
Examination of isotopic techniques used to measure geologic time, and their applications. Lectures, laboratories, research projects, field trips. Prerequisite: graduate standing in EES. May be repeated for credit. Bebout [fall odd years]

EES 438. Petrogenetic Processes (3)
Metamorphism, melting, and magmatism in the Earth's crust and mantle. Tectonic evolution, crust-mantle heat and mass transfer, fluid-rock interactions, and rate processes. Varying combinations of lecture and seminar formats. May be repeated for credit when topics differ. May include laboratory and field experience and computational exercises. Prerequisite: consent of course instructor. Bebout [spring even years].

EES 451. Advanced Topics in Limnology and Paleolimnology (3)
In-depth discussion of current issues in the fields of limnology and paleolimnology. Consideration of both the modern behavior of lake ecosystems, as well as lacustrine dynamics in the past based on interpretation of the fossil record. Topics may range from the interaction of lakes with their watersheds and the atmosphere to the dynamics of algal communities. Prerequisite: EES 351 or equivalent. Fritz [spring odd years].

EES 453. Advanced Topics in Microbial Ecology (3)
Lectures and seminars will focus on topics of current interest in the microbial ecology of pelagic (freshwater and marine), sediment, and/or soil environments. Emphasis will be placed on the role of microbes in ecosystems level processes such as energy transformations and elemental cycling. May include laboratory and field exercises. Prerequisite: graduate standing or consent of course instructor. Morris [spring even years]

EES 458. Advanced Ecology (3)
Seminars and conferences directed field work with emphasis on theoretical models and their application to real biological systems. May be taken more than once for credit. Prerequisite: EES 251 or equivalent. Williamson

EES 471. Stable Isotope Chemistry - Theory, Techniques, and Applications in the Earth and Environmental Sciences (3)
Distributions of stable isotope (primarily of O, H, C, S, and N) in the lithosphere, hydrosphere, biosphere, and atmosphere. Topics include mechanisms of fractionation and mixing, advancements in techniques for extractions and mass spectrometry, and recent applications of stable isotopes in the earth and environmental sciences. Lectures, seminars, laboratory sessions. Prerequisite: consent of instructor. Bebout

EES 473. Aqueous Geochemistry (3) spring (alternate even years)
Advanced study of physical and inorganic aqueous geochemistry, including homogeneous and heterogeneous equilibria, kinetics, and surface processes in water-rock systems. Computational modeling of water-rock systems. Prerequisites: EES 376 or equivalent, computer programming (C, Pascal, or Fortran), and consent of instructor. Moses

EES 484. Aquatic Ecosystems (3) fall (alternate even years)
Theoretical and experimental approaches to understanding physical and chemical influences in aquatic environments on organisms and their community, population, and systems ecology. Field trip. Prerequisite: graduate standing in EES. Staff

EES 487. Advanced Topics in Bio-Optics (3)
Bio-optics includes the ecosystem role and fate of solar radiation and the optical properties of biotic and abiotic components of ecosystems. This course will explore advanced topics through selected readings, data analysis, and modeling. Topics will emphasize aquatic ecosystems and may include optical models, atmospheric factors, inherent and apparent optical properties, algal fluorescence, photobiology, and photodamage, ultraviolet radiation, and optical stratification. Prerequisite: EES 484 or consent of course instructor. Hargreaves [fall odd years].

EES 490. Thesis Research (1-6)
Masters' thesis research directed by research committee. 3-6 credits required for EES M.S. programs. May be repeated for credit. Prerequisite: Permission of research adviser.

EES 491. Investigations in Earth and Environmental Sciences (1-6)
Research on a special problem; field, laboratory, or library study; report required. Credit above three hours granted only when a different problem is undertaken.

EES 492. Advanced Topics in Modern and Quaternary Processes (1-6)
Intensive study of topics in Modern and Quaternary geology not covered in more general courses. May be repeated for credit.

EES 493. Advanced Topics in Tectonics (1-6)
Intensive study of tectonic processes and products not covered in more general courses. May be repeated for credit.

EES 494. Advanced Topics in Aquatic Ecosystems (1-6)
Intensive study of aquatic ecosystems not covered in more general courses. May be repeated for credit.

EES 499. Dissertation Research (1-15)
Ph.D. dissertation research directed by research committee. May be repeated for credit. Prerequisite: Permission of research adviser.

Economics

Professors. J. Richard Aronson, Ph.D. (Clark), Clayton Professor; Thomas J. Hyclak, Ph.D. (Notre Dame), chair; Jon T. Innes, Ph.D. (Oregon); Arthur E. King, Ph.D. (Ohio State); John R. McNamara, Ph.D. (Rensselaer); Vincent G. Munley, Ph.D. (S.U.N.Y.); Anthony P. O'Brien, Ph.D. (Berkeley), Larry W. Taylor, Ph.D. (North Carolina); Robert J. Thornton, Ph.D. (Illinois), MacFarlane Professor.

Associate professors. Colleen M. Callahan, Ph.D. (North Carolina); Darlene Chisholm, Ph.D. (Washington); James Dearden, Ph.D. (Penn State); Mary E. Deily, Ph.D. (Harvard); Frank R. Gunter, Ph.D. (Johns Hopkins); Judith A. McDonald, Ph.D. (Princeton); Todd Watkins, Ph.D. (Harvard).

Instructor. J. R. Thomas, M.B.A. (Stanford)
Active emeriti. Nicholas W. Balabkins, Ph.D. (Rutgers); Alvin Cohen, Ph.D. (Florida); Eli Schwartz, Ph.D. (Brown).

Though economics is variously defined, modern-day definitions generally suggest that it is the study of the principles that govern the efficient allocation of resources. One of the greatest of the 19th century economists who did much to uncover these principles suggested a broader definition. Alfred Marshall described economics as "a study of mankind in the ordinary business of life... a part of the study of man." This dual nature of economics, technical and humanistic, is reflected in the fact that at Lehigh the economics major is available to students in the College of Arts and Sciences as well as in the College of Business and Economics.
As the description below suggests, the economics program is exceptionally flexible once one moves beyond the sophomore year. This flexibility allows the major to be adapted easily to the needs of students with widely varying goals. Although many students choose the economics major in order to secure a firm foundation in economics and finance before entering the business world, many others choose it in preparation for law school or as a complement to majors in political science, history, international relations, journalism, mathematics, urban studies or other disciplines. Naturally, many students who major in economics do so with the intent of pursuing graduate work at the master's or doctor of philosophy levels; others simply want to become "economically literate" in a world where such literacy is increasingly in demand.

At the same time that the program provides flexibility, it also consists of a substantial core of economic theory and related courses. This assures that the student who is uncertain concerning career goals will obtain a broad education in economics and business no matter what upper-level courses are chosen.

Students who are interested in designing a major program in economics suitable to their needs should consult with the major advisor and curriculum director.

Major in College of Business and Economics

Students in the College of Business and Economics electing to major in economics must take the college core courses listed in the College of Business and Economics section of this catalog. They must also take Eco 119 and at least 12 credit hours of 200 and 300-level economics courses beyond the core requirements. These courses may be chosen so as to form an area of specialization or to provide a broad exposure to the various aspects of the discipline. In any case, students should consult with the major advisor (Prof. J.R. Aronson) in forming their programs.

Major in College of Arts and Sciences

The study of economics leads to many possibilities, some of which involve formal education beyond a bachelor's degree, and others in which one immediately begins a career after graduation. The Department of Economics has established the following four tracks to meet the different needs of students who select economics as a major. Interested students should consult with Prof. Judith McDonald.

The tracks available to economics majors are:

I. Consulting/Financial Markets
II. Political Economy and Public Policy
III. International Economics and Global Markets
IV. Graduate Study in Economics

The four tracks have in common a core set of courses in economics, a core collateral course and four elective courses in economics. The common requirements are listed below. In addition, each of the four tracks are differentiated by additional requirements tailored to the need of the students in each track. The complete requirements for each track are described below.

**ECONOMICS CORE COURSES** (18 credits, required of all economics majors)

- Eco 1 Principles of Economics (4)
- Eco 105 or 115 Applied Microeconomics (3)
- Eco 119 Intermediate Macroeconomics (3)
- Eco 129 Money, Banking and Financial Markets (4)
- Eco 145 Statistical Methods (4)
- Eco 299 Money, Banking and Financial Markets (4)
- Eco 351 Mathematical Economics I (4)
- Eco 352 Mathematical Economics II (4)

**CORE COLLATERAL COURSE** (4 credits, required of all economics majors)

- Math 51 Survey of Calculus I (4)

(Students may substitute Math 21 for this course. Also see the additional requirements within each of the four tracks as listed below.)

**ELECTIVE COURSES** (12 credits, required of all economics majors)

Four upper-level (numbered at 200-level or beyond) economics courses. See information below on specific requirements by track.

**SUMMARY OF REQUIREMENTS FOR EACH TRACK**

I. Consulting/Financial Markets (42 credits)

**Description.** Especially intended for students who want to build a strong academic background in economics for immediate application to the world of business, consulting and financial markets. Excellent preparation for an MBA.

**Required economics courses.** Eco CORE courses and ELECTIVE courses, to be selected in consultation with the major advisor.

**Required collateral courses.** (a) CORE collateral course (Math 51), (b) Math 61, (c) Acct 151 and (d) Fin 125.

**Recommended additional collateral courses.** Acct 152 and Mkt 111.

II. Political Economy and Public Policy (44 credits)

**Description.** Especially intended for students who are interested in economics with a liberal arts emphasis, public policy analysis or law school.

**Required economics courses.** Economics CORE and ELECTIVE courses, to be selected in consultation with the major advisor.

**Required collateral courses.** (a) CORE collateral course (Math 51), (b) one course in each of the following areas: (i) history, (ii) political science and (iii) anthropology or sociology.

**Recommended additional collateral courses.** Courses in philosophy, especially Phil 128, 131, 133, 135 or 139.

III. International Economics and Global Markets (40 credits)

**Description.** Especially intended for students who are interested in careers in the international sphere, including multinational firms, and who desire a broad background in international economics and global markets.

**Required economics courses.** Economics CORE courses and ELECTIVE courses, including at least two of the following: Eco 209, 303, 305, 339, 340 or 343. These are to be selected in consultation with the major advisor.

**Required collateral courses.** (a) CORE collateral course (Math 51), (b) a course in non-US history and (c) a course in international relations.

**Recommended additional collateral courses.** Two or more semesters of foreign language study would be of great benefit. Students interested in international business would be well-served by a course in international marketing or multinational business finance, and should consult the catalog for prerequisites for such courses.

IV. Graduate Study in Economics (37 credits)

**Description.** Especially designed for students who intend to pursue a master's degree or doctorate in economics.

**Required economics courses.** Economics CORE and ELECTIVE courses, including either Mathematical Economics (Eco 351) or Econometrics (Eco 415), to be selected in consultation with the major advisor.

**Required collateral courses.** (a) CORE collateral course (Math 51) and Math 52. The following mathematics sequences may be substituted for Math 51 and 52: Math 21, 22 and 23, or Math 31, 32 and 33 (honors calculus).
Recommended additional collateral courses. (a) Math 205 and (b) Math 231 or 309. Students may substitute Math 231 for Eco 145. Interested students should consult the major advisor for a list of other useful mathematics courses.

HONORS IN ECONOMICS
Departmental honors will be awarded to graduating economics majors who have completed at least 15 credits of upper-level economics courses, or approved substitutes, and earned a major GPA of at least 3.25. One of the upper-level courses must be a senior honors project conducted under the supervision of a team of department faculty. Students interested in departmental honors should consult with the major advisor by the end of their junior year. Note: For the purposes of department honors, the major GPA will be computed with respect to all economics courses, or approved substitutes.

Minor in Economics
A minor in economics consists of 12 credit hours beyond Eco 1. Required courses in the minor are: Eco 105 or 115, 119 or 129 and two elective courses. Elective courses must be chosen from among the 200 and 300-level economics offerings. This minor is available only to students in the College of Arts and Science and in the College of Engineering and Applied Science. Interested students should contact Prof. Vincent Munley.

Undergraduate Courses

Eco 1. Principles of Economics (4)
A one-semester course in the principles of economics. General topics covered are: supply and demand; pricing and production decisions of firms; the role of government in the economy; the determination of national income; money and banking; monetary and fiscal policy; and government finance. (SS)

Eco 11. Principles of Microeconomics (3)
This course is an introduction to basic economic concepts, theory, and institutions. It emphasizes the application of economic analysis to a variety of problems. Topics include supply and demand; consumer choice and behavior; pricing and production decisions of firms; the role of government in the economy; labor markets and unions. Not available for credit to students who have taken Eco 1. (SS)

Eco 12. Principles of Macroeconomics (3)
This course extends the application of economic analysis to the macroeconomy. Topics include the measurement and determination of national output; the banking system and money supply; monetary and fiscal policy; unemployment and inflation; international trade and the balance of payments. Not available for credit to students who have taken Eco 1. (SS)

Eco 21. Introductory Microeconomics (2)
Supply and demand, consumer behavior, theory of the firm and the role of government in the economy. The student will be scheduled for the appropriate part of Economics 1. Prerequisite: three hours of advanced placement or transfer credit for Eco 12, and the consent of the department chair. (SS)

Eco 22. Introductory Macroeconomics (2)
Measurement and determination of national output, the banking system and money supply, monetary and fiscal policy, unemployment and inflation, international trade and the balance of payments. The student will be scheduled for the appropriate part of Economics 1. Prerequisite: three hours of advanced placement or transfer credit for Eco 11, and the consent of the department chair. (SS)

Eco 105. Intermediate Microeconomic Analysis (3)
Determination of prices in terms of the equilibrium of the business enterprise and consumer choice in markets of varying degrees of competition; analysis of market structures; determination of wages, rent, interest and profits. Prerequisite: Eco 1. Not available for credit to students who have taken Eco 115. (SS)

Eco 115. Applied Microeconomic Analysis (3)
The application of economic analysis to managerial and public policy decision making. Prerequisite: Eco 1, 145 and a course in Calculus (Math 51, 21 or 31). Not available for credit to students who have taken Eco 105. (SS)

Eco 119. Intermediate Macroeconomic Analysis (3)
Macroeconomic measurement, theory and policy. The use of alternative macroeconomic models to analyze the level of national income, inflation, unemployment, economic growth; the balance of payments, and exchange rate determination. Prerequisite: Eco 1. (SS)

Eco 129. Money, Banking, and Financial Markets (4)
The nature and functions of money. Global money and financial markets. The role of commercial and central banks. Effects of the interest rate, exchange rate, and the money supply on the economy. Examination and evaluation of current and past monetary policies. Prerequisite: Eco 1. (SS)

Eco 130. (WS30) Economics of Race and Gender (2)
The question of the role of race and gender in economic decision-making is explored. Various sorts of discrimination are discussed in an economic framework and possible remedies are evaluated. The historical role of race and gender in the economy is also discussed. Prerequisite: Eco 1. (SS)

Eco 131. The Canadian Economy (2)
This course analyzes the economic challenges facing the Canadian economy. Some of the issues include: Canada's record on inflation and unemployment; the distribution of income; the role of natural resources; Canada's health-care and educational systems. Canada's monetary and fiscal policies, and Canada's performance in the international economy will also be examined. Prerequisite: Eco 1. McDonald (SS)

Eco 133. Economics of the Sports Industry (2)
This course analyzes the role of basic economic forces in shaping today's sports industry. Topics include: competition in the market for professional franchises; public subsidies for stadiums and arenas, compensation of professional athletes, the NCAA as an economic enterprise; and the impact of athletics on a university's budget. Prerequisite: Eco 1. Munley, Sterrett. (SS)

Eco 134. Evolution of the Automobile Industry (2)
This course traces the development of the automobile industry from its origin at the turn of the century to the present. Topics include: the Model T and mass production; the development of installment purchases; dealer-company relations; worker-employer relations; the rise of import; and the decline of traditional mass production. Prerequisite: Eco 1. King, O'Brien. (SS)

Eco 145. Statistical Methods (4)
Descriptive statistics, probability and probability distributions, sampling, estimation, hypothesis testing, regression and correlation, analysis of variance, nonparametric tests, and index numbers. (ND) Note: Students may not have credit for both Math 12 and Eco 145.

For Advanced Undergraduates And Graduate Students

Eco 209. Comparative Economic Systems (3)
An analysis of the micro- and macro-economic, institutional and political dimensions of various economic systems, with particular emphasis on former centrally planned economies in their transition to a market orientation. Prerequisite: Eco 1. King (SS)
Eco 210. Economic Evolution (3)
Structural changes, social transformation, and sources of the long-term growth of the U.S. economy. Prerequisite: Eco 1. O'Brien (SS)

Eco 231. Business History (3)
The historical context of the development of the modern business firm in the United States. The roles of entrepreneurship, economic structure, technology, and government policy in the shaping of current business practices. Prerequisite: Eco 1, Eco 145 is recommended. O'Brien (SS)

Eco 234. Labor-Management Relations (3)
An analytical study of the U.S. system of industrial relations, including the evolution of the labor movement, worker choice on the issue of union representation, the process of collective bargaining and the impact of collective bargaining on the management of the firm. Prerequisite: Eco 1. Hyclak (SS)

Eco 235. Labor Economics (3)
The economic analysis of labor markets, with emphasis on labor supply and demand, wage and employment theory, and the economics of unionism and other labor market institutions. Prerequisite: Eco 1. Thornton (SS)

Eco 237. Transportation Economics (3)

Eco 246. Business Cycles and Forecasting (3)
A study of short-term business fluctuations, growth, forecasting and stabilization. Prerequisites: Eco 1 and a course in statistics. (ND)

Eco 303. Economic Development (3)
Economic development, economic growth and their political environment are discussed in detail. The principal economic development theories are examined. These theories are used to examine a variety of development issues including planning, poverty, rural-urban relationships, physical and human capital accumulation, international trade, and the environment. Emphasis on institutions and development policy. Prerequisite: Eco 105 or 115. Gunter (SS)

Eco 305. The Economic Development of Latin America (3)
The course examines the forces at work in the development process in Latin America. Variables considered include the social and political as well as the economic ones. Topics are presented along with their application via the examination of country case studies. Prerequisite: Eco 105 or 115. Gunter (SS)

Eco 311. Environmental Economics (3)
Resource allocation implications of environmental degradation. Analysis of the benefits and costs associated with alternative pollution control programs and strategies. Prerequisite: Eco 105 or 115. Munley (SS)

Eco 312. Urban Economics (3)
The analysis of economic problems related to urban areas; the nature and function of cities; the economic and spatial characteristics of urban activity. Prerequisite: Eco 105 or 115. Hyclak (SS)

Eco 313. History of Economic Thought (3)
A survey of the important historical writings that form the foundation of today's mainstream economic theory. Emphasis is on the period from 1750 to 1950 and on such notable economists as Smith, Ricardo, Walras, Marshall and Keynes. Prerequisite: Eco 105 or 115 or 119. Innes (SS)

Eco 314. Energy Economics (3)
The economic theory of natural resource allocation over time. Economics of exhaustible and renewable resources. Environmental effects of energy production and consumption. Government regulation of the energy industry. Computer models for energy system forecasting and planning. Prerequisite: Eco 105 or 115. McNamara (SS)

Eco 315. Industrial Organization (3)
Structure of American industry. Development of economic models to describe behavior in markets with varying degrees of competition. Technological innovation, relationship between industry concentration and rates of return on capital, role of information and advertising, dynamics of monopoly and oligopoly pricing. Prerequisite: Eco 105 or 115. Chisholm (SS)

Eco 332. Monetary-Fiscal Policy (3)
Monetary, credit and fiscal policies of governments and central banks with particular reference to the policies of the United States Treasury and the Federal Reserve System. Prerequisite: Eco 119 or 129. Innes (SS)

Eco 333. Managerial Economics (3)
Models of managerial decision-making. Emphasis on the application of economic theory to a variety of business problems. Case studies are employed. Prerequisites: Eco 105 or 115; 145 and a calculus course or consent of instructor. McNamara (SS)

Eco 336. Business and Government (3)
Analysis of government involvement in the private sector. The problems of monopoly, oligopoly, and externalities in production and consumption. Optimum responses to market failure and analysis of the performance of actual government policies. Prerequisite: Eco 105 or 115. Deily (SS)

Eco 339. International Trade (3)
The theory of international trade; the theory of tariffs; United States commercial policies; the impact of growth and development of the world economy. Prerequisite: Eco 105 or 115. McDonald (SS)

Eco 340. International Finance (3)
Analysis of balance of payments and disturbances and adjustment in the international economy; international monetary policies. Prerequisite: Eco 129. Staff (SS)

Eco 343. European Economic Integration (3)
Study of the problems of economic integration throughout Europe, especially in the Post-Cold War era among Western, Central and Eastern European nations. Prerequisite: Eco 209 (may be taken concurrently with permission of instructor). King (SS)

Eco 351. Introduction to Mathematical Economics (3)
Application of mathematical techniques to economic problems of optimization and to economic models. Prerequisites: Eco 105 or 115 and 119 and a calculus course. Chisholm (ND)

Eco 352. Advanced Statistical Methods (3)
Advanced probability theory, probability and sampling distributions, and classical statistical inference. Index numbers, multiple regression, correlation, and analysis of variance. Spectral analysis, Box-Jenkins auto-regressive and moving average stochastic processes. Prerequisites: Eco 105 or 115 and a course in statistics. Taylor (ND)

Eco 353. Public Economics and Government Finance: Federal (3)
A course dealing with the expenditures and revenues of the federal government. Major topics include public choice theory,
benefit-cost analysis, the theory of public goods, the economics of taxation and the design of tax structures. Prerequisite: Eco 105 or 115. Aronson (SS)

Eco 354. (Fin 354) Public Economics and Government Finance: State and Local (3)
A course dealing with the expenditures and revenues of state and local governments. Major topics include the theory of fiscal federalism, intergovernmental fiscal transfers, the design of state and local tax structures, capital budgeting and debt finance, pension funds and school finance. Prerequisite: Eco 105 or 115. Aronson, Munley (SS)

Eco 357. Econometrics (3)
Problems in construction, evaluation and use of econometric models. Applications based on research and case studies. Prerequisites: Eco 105 or 115 and 119 and a course in statistics. King (ND)

Eco 358. Game Theory (3)
A mathematical analysis of how people interact in strategic situations. Applications include strategic pricing, negotiations, voting, contracts and economic incentives, and environmental issues. Prerequisites: Eco 105 or 115 and 119 and a course in game theory. Dearden (SS)

Eco 361. Senior Seminar (3)
Intensive study and discussion of significant topics in economic policy and theory. Prerequisite: senior standing as economics major or consent of department chairman. (SS)

Eco 362. Martindale Research Seminar (1-3)
This course prepares students to undertake research on various topics in business and/or economics. Admission to this course is limited to student associates of the Martindale Center for the Study of Private Enterprise. Consent of the instructor is required. Course may be repeated for credit up to a maximum total number of 3 hours credit. (ND)

Eco 368. Health Economics (3)
Supply and demand in the health service markets for the U.S. and Canada. Unique features of health care which interfere with competitive market allocation and pricing. Overview of insurance systems and other payment methods. Prerequisites: Eco 105 or 115 and a course in statistics. King (SS)

Eco 371. Special Topics in Economics (1-3)
Study in various fields of economics, designed for the student who has a special interest in some field of economics not covered by the regularly scheduled courses. Prerequisite: preparation in economics acceptable to the department chair. (ND)

Eco 372. Special Topics in Economics (1-3)
Continuation of Eco 371.

Eco 389. Honors Project in Economics (3)
A course intended for undergraduate majors who are pursuing an extended project for honors in economics under the supervision of a faculty member. Interested students should consult the description of the honors program listed in this catalog. Senior standing and department permission required. May be repeated for credit. (ND)

Course descriptions for the College of Business and Economics graduate courses can be found in this section (Section V) under the heading of Business and Economics Graduate Courses.
The department offers master’s degrees and/or professional certification in counseling and human services, educational technology, educational leadership, elementary and secondary education, school counseling, and special education as well as the Ed.S. degree and professional certification in school psychology and special education. Ed.D. degree programs are offered in curriculum and instruction, educational leadership, educational technology, and elementary education. Ph.D. degrees are offered in counseling psychology, school psychology, and special education. While general courses are listed separately, the courses pertinent to each program are listed below.

Education

Educ 312. Classroom Practice (1-3)
Experience in elementary and secondary classrooms as related to theories of child and adolescent development, classroom didactics, and philosophies of education. Problem-centered discussion and observations. Prerequisite: consent of the program director.

Educ 313. Intern Teaching (3-6)
Intensive practice in the application of the principles of teaching. Supervision is provided by the cooperating school and by the university. Prerequisite: consent of the program director.

Educ 314. Seminar in Elementary and Secondary Education (1-3)
Critical analysis and discussion of classroom instructional practices based on experiences of participants as they engage in teaching experiences. Prerequisite: consent of the program director.

Educ 321. The Writing Process (3)
Developmental characteristics of children's writing and relationships among writing, spelling and reading. Predictors of writing achievement, teaching strategies and activities, and evaluation schemes will be emphasized, K-12.

Educ 343. The Disadvantaged Student (3)
Philosophical analyses of disadvantage and relevant educational theories. Applications and evaluations of special methods and techniques.

Educ 383. Supervised Research in Applied Psychology (1-3)
Provides undergraduate junior and senior psychology majors a formal supervised research experience in applied psychology. Students are assigned for the semester to a research team led by a participating faculty member in the counseling psychology or school psychology programs in the College of Education. (Repeatable up to 6 credits.)

Educ 388. Statistical Computing (3)
Use of one or more major statistical software packages. Principles of data coding, editing, integrity checking, and management. Emphasis on link between personal computers, mainframes, and other software. Prerequisite: Educ 408 or consent of instructor.

Educ 391, 2. Workshops (1-3)
Cooperative study of current educational problems. Provides elementary, secondary, and special education teachers an opportunity to work at their own teaching levels and in their own fields. Limited to six credits during a summer session but the student may register for more than one workshop provided there is no duplication in subject matter.

Educ 394. Special Topics in Education: (with subtitle) (3)
Examination of a topic of research or professional interest in education. Subtitle will vary. May be repeated for credit as subtitle varies.

Educ 401. Sociological Foundations of Education (3)
The American school as a social institution, its cultural heritage, its purposes and processes in relation to social change and educational leadership; its role in socialization and its responsibilities for relevance to social issues and to subcultural needs.

Educ 402. (Psyc 402) Developmental Psychology (3)
Survey of theories and research concerning perceptual, cognitive, social, and personality development through infancy and childhood. Prerequisite: Graduate standing or consent of instructor.

Educ 403. Research (3)
Basic principles of research; techniques of gathering and analyzing data; design of studies in education. Emphasis on critical reviews of research reports representing various methodologies. Research report required.

Educ 404. Introduction to Testing and Evaluation (3)
Construction and evaluation of the teacher-made test. Selection of published tests and interpretation of individual and group results. Use and misuse of tests in assessing achievement.

Educ 405. Comparative Education (3)

Educ 406. Historical Foundations of Education (3)
Development of primary, secondary, and higher education; aims, curricula, methods, and systems of schooling in America from colonial time to present, in relation to social conditions.

Educ 407. Philosophical Foundations of Education (3)
Comparative philosophical analysis of educational aims, practices, and institutions. Major philosophical theorists whose work has influenced educational thought.

Educ 408. Introduction to Statistics (3)
Organization and description of data. Principles of statistical inference including hypothesis testing, interval estimation, and inferential error control. Emphasis on application.

Educ 409. Analysis of Experimental Data (3)
Emphasis on analysis of variance designs including one-way, factorial, nested, and repeated measures designs. Introduction to multiple regression and the analysis of covariance. Prerequisite: Educ 408 or consent of instructor.

Educ 410. Univariate Statistical Models (3)
The univariate general linear model. Principles of expressing models and hypotheses about those models. Emphasis on similarity among the analysis of variance, multiple regression, and the analysis of covariance. Examples of non-standard models and generalization to complex designs. Prerequisite: Educ 409 or consent of the instructor.

Educ 411. Multivariate Statistical Models (3)
The multivariate general linear model. Principles of expressing multivariate models and hypotheses about those models. Emphasis on similarity among the multivariate analysis of variance, multiple regression, and the analysis of covariance. Examples of non-standard models and generalization to complex designs. Prerequisite: Educ 410 or consent of the instructor.

Educ 412. Advanced Applications of Psychometric Principles (3)
Conceptual examination of exploratory and confirmatory factor analysis, cluster analysis, latent-trait modeling, and other advanced psychometric topics. Prerequisites: Educ 409 or equivalent, SchP/CPsy 427 or SpEd 408.
Educ 413. Intern Teaching (3-6)
Intensive practice in the application of principles of teaching. Supervision is provided by the cooperating school and by the university. Prerequisite: consent of the program director.

Educ 414. Intern Teaching Seminar (3)
Critical analysis and discussion of classroom instructional practices. Discussion and illustration based on experience of participants as they engage in intern teaching. Prerequisite: consent of the program director.

Educ 415. Classroom Didactics (3)
Initial preparation of interns for classroom teaching. Secondary interns are trained in teaching methods in subject fields and the reading problems of secondary students. Elementary interns study teaching methods in the elementary school. Open to teaching interns only.

Educ 416. (SR 416) Quasi-Experimentation and Program Evaluation (3)

Educ 417. Participation in Teaching (3)
Study, directed observation of, and initial practice in the various phases of teaching in a laboratory-demonstration school or in area elementary and secondary schools. Prerequisite: consent of the program director.

Educ 418. Science in Elementary Education (3)
Principles of the elementary science program. Demonstrations and discussions of appropriate materials and techniques for teaching science concepts to elementary school students.

Educ 419. Mathematics in Elementary Education (3)
Mathematical skills and concepts for the elementary school program. Sets, systems of numeration, experience with numbers, operations with numbers, number concepts and numerals, and elements of geometry.

Educ 421. Materials in Reading (3)
Provides examination and critical analysis of published and unpublished reading materials used in instruction from kindergarten through adult levels. Prerequisite: Educ 426 or consent of the program director.

Educ 422. Language Development of Children (3)
The nature of language and its relation to the development of communication skills. Critical analysis of related research. Implications for the elementary school.

Educ 423. Curriculum and Instruction in Social Studies (3)
Curriculum, content, teaching strategies, and instructional materials of the social studies field. Emphasis will be placed on organizing content, using appropriate methods, testing and evaluation, and innovations for social studies at the elementary, middle, and high school levels. Attention will be given to examining textbooks, courses of study, and teacher-made materials.

Educ 424. Developmental Reading (3)
Introductory course spanning the elementary and secondary levels. Reading methods, materials, the disadvantaged and gifted reader, procedures for individualized reading instruction.

Educ 426. Diagnosis and Adjustment of Reading Difficulties (3-6)
Psychology of reading related to learning difficulties; measurement and diagnosis of reading difficulties; development of informal tests; materials for corrective and/or remedial instruction. Prerequisite: Educ 424 or consent of the program director.

Educ 427. Children’s Literature in Reading Instruction (3)
Role of literature in the instructional program of the elementary schools. Use of trade books for individual instruction in reading.

Educ 428. Reading in the Content Areas (3)
Focuses on expository reading development in content areas such as language arts, mathematics, science and social studies. Practical teaching strategies in critical areas, such as comprehension and study skills. Review of research and methods for improving the reading development of students.

Educ 429. Child Development (3)
A study of physical, intellectual, emotional and social aspects of child development as they relate to the elementary schools.

Educ 430. Advanced Topics in Reading (3)
Theory and research in historical background of reading instruction; cognitive, affective, and linguistic aspects of reading; implications for the disadvantaged and gifted reader. Field experience required. Prerequisite: Educ 424 or consent of the program director.

Educ 431. Critical Thinking in Reading (3)
An understanding of the reading/thinking process and its relationship to logic, leading to the ability to analyze, criticize and advocate ideas and to reach factual or judgmental conclusions based on inferences drawn from the printed word. Implications and methods for teaching elementary through college-level students will be addressed.

Educ 432. Reading Specialists Clinic (6)
Concentrates on diagnosis of reading problems and disabilities and the remediation of the deficits in children. Requires the graduate student to work with reading-disabled children for 125 clock hours.

Educ 433. Mathematics in Middle Level and High School Education (3)
Curricula, instructional activities, and manipulative aids applicable to mathematics courses in middle level and high schools. Teaching strategies and materials appropriate for teaching mathematics will be emphasized. Permission of the instructor.

Educ 434. Seminar in Reading Research (3)
An advanced course dealing with critical appraisal and discussion of classical and current studies in reading.

Educ 435. Adult Literacy (3)
The magnitude of illiteracy in the United States and its implications will be covered. Characteristics of the adult learner will be addressed as well as appropriate assessment strategies and instruments, methods of instruction, materials and programs. Program funding and development will be explored.

Educ 436. Practicum in Supervision of Reading Program (3)
For candidates for supervisor’s certificate in reading. Organization of the instructional processes in reading programs. Participants in supervisory activities.

Educ 437. Science in Middle Level and High School Education (3)
Curricula, philosophy, methodology, strategies and safety in the teaching of middle and high school science. Emphasis on laboratory and instructional technology, at-risk and underrepresented students and current models of science education. Permission of the instructor.
Educ 438. Programs for Gifted and Talented (3)
Characteristics of gifted children; teaching gifted children; programs for the gifted in elementary and secondary schools.

Educ 441. Youth in Society (3)
Social development, characteristics, and problems of adolescents and young adults. Impact of relationships with sibling, peers, adults, subcultures, in the context of changing institutions and values.

Educ 442. Introduction to Bilingual/Bicultural Education (3)
An overview of the social, political, and legal contexts influencing the development and implementation of a bilingual education. Programs, methods, and empirical research in the field of bilingual education will be explored as will the development and implementation of an education that is authentically bilingual and bicultural.

Educ 443. Bilingual/Bicultural Families as Educators (3)
Research knowledge, experiential learning and related applications based upon the realities of growing up bilingual in our society. Emphasis is placed upon a non-deficit philosophy, exploring the strengths and unique contributions of bilingual families in the cognitive and social development of children.

Educ 444. Program Design in Bilingual/Bicultural Education (3)
Knowledge, competencies, and understandings relating to programmatic (curricular, instructional) design of bilingual programs will be explored. Innovative empirically-based integrative bilingual/bicultural education models will be designed.

Educ 447. Assessment Principles for Bilingual/Bicultural Learners (3)
Research and practical knowledge regarding optimal methods of assessment for bilingual learners. Educational issues faced by bilingual learners resulting from assessment strategies and alternate paradigms will be the major focus.

Educ 448. Qualitative Research Practicum in Bilingual/Bicultural Settings (3)
Research knowledge, competencies, and understandings relating to qualitative research with bilingual, bicultural populations. Practical applications, appraisal of the current state of the art, and exploration of innovative designs will be emphasized.

Educ 450. Curriculum Construction (3)
Theoretical models of curriculum design and evaluation. Scope, sequence, articulation, continuity, and balance in designs. Organizing for curriculum planning, development, implementation and change. K-12.

Educ 451. (Psyc 451) Theories of Learning (3)
In-depth study of major classical and contemporary learning theories. Review of experimental research relevant to theories.

Educ 456. School Curriculum (3)
Curricular innovations. Applications of curricular designs K-12. Subject matter and course design. Integration and importance of the fine arts and physical education in the curriculum.

Educ 460. Program Evaluation (3)
The historical background, theory, methodology, and current practices of program evaluation in the human services area. Emphasis will be placed on conducting evaluations of educational programs. Current research will be conducted and an examination of on-going program evaluations will be conducted.

Educ 461. Single-Subject Research Design (3)
Experimental designs for use with small N's. Topics include design theory and application, experimental validity (internal, external, statistical conclusions and construct validity) and an overview of data analysis procedures.

Educ 471. (Psyc 471) Multicultural Issues (3)
Examination of the influence of culture, gender, and disabilities on behavior and attitudes. Historical and current perspectives on race, culture, gender, and minority group issues in education and psychology. Lecture/small group discussion.

Educ 473. (SR 473) Social Basis of Human Behavior (3)
Development of human behavior from a social psychological perspective. Emphasis placed on the impact of society upon school-age children and adolescents.

Educ 486. Doctoral Qualifying Research Project (1-3)
Design and implement research project under faculty supervision to meet requirements for doctoral programs. May be repeated for credit.

Educ 491, 2. Advanced Seminars: (with subtitle) (1-6)
Intensive study and discussion of a specialized area. Title will vary. May be repeated for credit as title varies.

Educ 493. Internship in: (with subtitle) (3)
Opportunity for advanced students to obtain practical experience. Conference hours for students and staff members devoted to discussion of work and problems encountered in the school. Prerequisite: consent of the program director.

Educ 494. Field Work in: (with subtitle) (3)
Identification of significant problems in an educational environment, review of the literature, and development of appropriate research plans.

Educ 495. Independent Study in: (with subtitle) (1-6)
Individual or small group study in the field of specialization. Approved and supervised by the major adviser. May be repeated.

Educ 496. Doctoral Research Seminar (3)
For doctoral students. Research design and application to various kinds of educational problems; data collection and analysis. Criticism and evaluation of student proposals. May be repeated for a maximum of nine credits.

Educ 497. Advanced Doctoral Seminar in Curriculum and Instruction (with subtitle) (3)
Seminar on special topics such as curriculum management, integration of curriculum, middle school curriculum, etc. May be repeated for credit. For doctoral students or with the consent of the instructor.

Counseling Psychology

Psyc 427. (SchP 427) Standardized Tests, Measurement and Appraisal (3)
Principles of psychological measurement (e.g., tests construction, technology, validity, reliability, functional utility). Ethical, legal, and cultural issues in the administration and interpretation of psychological tests. Case conceptualization, reporting and presentation.

Psyc 429. Diagnostic Interview Laboratory (1)
Principles of psychological measurement (e.g., tests construction, technology, validity, reliability, functional utility). Ethical, legal, and cultural issues in the administration and interpretation of psychological tests. Case conceptualization, reporting and presentation. One-credit diagnostic laboratory is mandatory for counseling majors but optional for students from other programs. Lab covers diagnostic interviewing and systems for the identification and classification of behavioral and psychological disorders.
Theory, research, and technique of counseling and selection of group members; group rules; group procedure systems.

CPsy 462. Assessment of Personality (3)

Consideration of psychological and cross-cultural issues in adult intelligence and neuropsychological functioning. Preparation of psychological reports. Prerequisites: CPsy 427 and permission of the instructor.

CPsy 463. Assessment of Personality (3)
Consideration of issues and methods of personality assessment, including ethical and legal issues, and cross-cultural issues. Practice in the administration of instruments used for personality assessment. Supervised experience and report writing. Prerequisites: CPsy 427 and admission to the Ph.D. program in counseling psychology.

CPsy 464. Current Issues in Counseling and Therapy (1-6)
Examination of an area of counseling or therapy that is of topical interest to students and faculty. Permission of program director required. May be repeated for credit.

CPsy 466. Independent Study and Research (1-6)
Individual or small group study in the field of counseling. Approved and supervised by the major adviser. May be repeated for credit.

CPsy 471. (Educ 471) Multicultural Issues (3)
Examination of the influence of culture, gender, and disabilities on behavior and attitudes. Historical and current perspectives on race, culture, gender, and minority group issues in education and psychology. Lecture/small group discussion.

CPsy 472. Human Development Across the Lifespan (3)
An examination of prevailing theories of human growth and development across the lifespan. Examination of the interactive effect of various age groups upon one another. Particular emphasis on the helping relationships.

CPsy 473. (SchP 473) Advanced Research Methods in Applied Psychology (1-3)
For doctoral students in applied psychology. Issues and methods of research design, data collection and data analysis. Advanced discussion of quantitative, qualitative and single-case research design. Admission to the Ph.D. program in counseling psychology or school psychology or permission of the instructor.

CPsy 476. Supervision of Counseling (1-6)
For candidates for supervisor's certificate or doctorate in counseling. Observation and supervision of counseling practicum students. Prerequisites: CPsy 480 and permission of instructor.

CPsy 480. Practicum (1-4)
Twenty hours of weekly supervised practicum training for advanced graduate students in individual, group, and family counseling and therapy. Prerequisites: CPsy 440.

CPsy 481. Advanced Multicultural Counseling (3)
This seminar covers models and theories of multicultural counseling and intervention. Students should be actively engaging in practice with multicultural clients in a practicum or field site, and these cases will form part of the basis of course discussions. Prerequisites: CPsy 471, admission to the doctoral program in counseling psychology, and permission of the counseling psychology program coordinator.

CPsy 483. Field Work in Counseling (3-6)
Twenty hours of weekly supervised professional practice in a school or agency setting as an extension of CPsy 480. Practicum. On-site supervision, audio and/or video recordings and case presentations required. Prerequisites: CPsy 480 and permission of the counseling psychology program coordinator.

CPsy 485. Advanced Psychopathology (3)
This class will cover etiology, assessment, interviewing techniques, establishing a therapeutic alliance, and treatment planning in adult mental disorders. In depth coverage will be given to Axis II disorders. The diagnosis and classification of abnormal behavior using DSM-IV-R medical model will be emphasized. Alternate theories of abnormal psychology will also be discussed. Prerequisite: Psych 435, Abnormal Psychology.

CPsy 486. Family Counseling Clinic (3-6)
Supervised practicum training for advanced graduate students in family counseling and therapy. Techniques and methods of conducting family counseling and therapy. Prerequisites: CPsy 480 and CPsy 440.
CPsy 487. Advanced Doctoral Practicum I (4)
Supervised clinical experience for entry-level doctoral students with emphasis on the development of intake skills, assessment procedures and intervention skills. Audio and video recording, individual and group supervision. Prerequisite: Admission to the doctoral program in counseling psychology and permission of the counseling psychology practicum coordinator.

CPsy 488. Advanced Doctoral Practicum II (4)
Supervised clinical experience with emphasis on advanced skills in interpretation, case conceptualization from a theoretical perspective, termination and referral, and in the broad array of professional activities normally conducted by a counseling psychologist. Audio and video recording, individual and group supervision. Prerequisites: CPsy 487 and permission of the counseling psychology practicum coordinator.

CPsy 489. Advanced Doctoral Practicum III (4)
Supervised field experience in counseling and therapeutic settings for doctoral students with specific populations. In consultation with on-site supervisor, the student will develop an area of focus for this practicum that will include therapy experience, training and additional assessment skills as needed. Repeatable for a total of 3 credits. Prerequisites: CPsy 487 and permission of the counseling psychology practicum coordinator.

CPsy 491. Advanced Doctoral Practicum IV (4)
Supervised field experience in counseling and therapeutic settings for doctoral students with specific populations. In consultation with on-site supervisor, the student will develop an area of focus for this practicum that will include therapy experience, training and additional assessment skills as needed. Repeatable for a total of 3 credits. Prerequisites: CPsy 489 and permission of the counseling psychology practicum coordinator.

CPsy 498. Counseling Psychology Doctoral Internship (1)
A one year full-time or two year half-time supervised internship in professional psychology. Student functions as regular staff member. Regular contact with academic advisor required in addition to end-of-semester evaluation by the internship site and the student. Prerequisite: CPsy 491 and permission of the counseling psychology program coordinator. (Repeatable for a total of 3 credits).

Educational Leadership

EdL 400. Introduction to Organizational Leadership: Theory and Practice (3)
Development of theories of administration and applications in educational institutions. Administrative behavior in organizational settings; administrator's leadership role in decision-making, evaluation, and conflict resolution.

EdL 405. The Principalship (3)
Major problems of organization and administration of schools, types of organization, pupil promotion, program of studies, teaching staff, pupil personnel, contract management, time allotment, plant and equipment, and community relations. Prerequisite: EdL 400.

EdL 406. School Principals Clinic (3-6)
Simulated materials workshop on administrative decision-making open to practicing and prospective elementary and secondary school administrators.

EdL 457. Performance Appraisal (3)
Essential elements for the evaluation of school teachers, principals and superintendents. Research-based constructs as well as practical applications. The course is intended primarily for future and practicing school administrators.

EdL 466. Supervision of Instruction (3)
Analysis of the principles underlying the organization and supervision of instruction; application to specific teaching situations K-12.

EdL 469. Advanced Instructional Supervision (3)
A staff development approach to supervision designed to extend the supervisor's knowledge of and skills in applying clinical techniques to instructional supervision.

EdL 470. Special Topics in Educational Leadership: (with subtitle) (1-6)
Intensive study and discussion of a specialized area. Title will vary. May be repeated for credit as title varies.

EdL 473. Human Resources Management (3)
Overview of the effective utilization of the human resources of educational organizations. Trends in human resource planning, recruitment, selection, development, evaluation, compensation and contract administration.

EdL 476. School Financial Management (3)
Theoretical and practical foundation in financial management emphasizing the economics of education, financing and distribution of funds, and the management of funds at the school and district level.

EdL 477. Seminar in School-Community Relations (3)
Analysis and development of the communication and public relations skills needed by educators in dealing with the public.

EdL 478. Collective Bargaining in the Schools (3)
Contract negotiations, grievance, mediation, and arbitration for both professional and classified employees in education.

EdL 479. School Law (3)
Effect of school law on administration of public school systems; analysis and synthesis of judicial interpretations of the constitutions, statutes, rules, regulations, and common law relating to educational issues.

EdL 481. Policy and Politics in Public Education (3)
Analysis of the forces, factors, agencies, formal governmental systems and informal subsystems that influence educational policy in local districts and state and national governments.

EdL 485. The Superintendency (3)
A theoretical and historical examination of superintendents' leadership, school board/superintendent relations, and the array of duties and demands upon the superintendency.

EdL 489. Doctoral Seminar in School Administration (3)
Analysis of the theoretical, empirical, and conceptual aspects of contemporary issues in educational administration and their implications for policy formulation and implementation in educational institutions. Prerequisite: Official standing as a doctoral student in educational leadership.

Educational Technology

EdT 404. Interactive Multimedia Programming (3)
Introduction to programming interactive multimedia applications in education and training. Emphasis on using event-driven, object-oriented programming to design and create applications utilizing sound, video, graphics and computer animation. Must be taken with accompanying laboratory (EdT 414).

EdT 405. Hypermedia Theory and Applications (3)
Analysis of the theory of hypermedia and multimedia. Emphasis on the examination of current practices and research in hypermedia. Complementary course to courses on multimedia programming. Must be taken with accompanying practicum (EdT 415).
EdT 406. Advanced Multimedia Design and Programming (3)
Advanced hypermedia programming techniques applied to the
design and delivery of technology-based instruction. Application
and design of 3-D animation, digital audio and video. Must be
taken with accompanying laboratory (EdT 416). Prerequisite:
EdT 404 or consent of instructor.

EdT 407. Foundations of Educational Technology (2)
Events, philosophies, and practices instrumental in the evolution
of the field of educational technology. Current and projected
trends in the use of technology in education and training. Topics
such as technology-based school restructuring, computer-based
cognitive science for instructional design and technology use,
and information infrastructure technologies. Must be taken with
accompanying practicum (EdT 417).

EdT 414. Interactive Multimedia Laboratory (1)
Laboratory for location and production of multimedia resources.
Must be taken with EdT 404, Interactive Multimedia Programming.

EdT 415. Practicum in Hypermedia/Multimedia Learning (1)
Exploration of learning with hypermedia / multimedia. Must be
taken with EdT 405, Hypermedia Theory and Applications.

EdT 416. Advanced Interactive Multimedia Laboratory (1)
Advanced laboratory for the location and production of
multimedia resources. Must be taken with EdT 406, Advanced
Multimedia Design and Programming.

EdT 417. Practicum in Educational Technology Foundations (1-2)
Complementary learning activities and exercises in the use
of technology-based learning materials. Must be taken with EdT
407, Foundations of Educational Technology. May be taken for
one or two hours of credit.

EdT 418. Desktop Publishing (3)
This course emphasizes the application of visual design
technologies required to create and publish electronically-
prepared documents. The creation of high-quality text and
special graphics effects will be examined. Advanced technologies
related to desktop publishing such as optical character
recognition, color printing theory and digital video will be
included.

EdT 420. Media Production for Instructional Programming (3)
Applications in the design, production, editing, and evaluation of
educational video tapes. Students will gain hands-on experience
designing, filming, editing, and producing educational learning
materials in a studio production center.

EdT 428. Advanced Interactive Computing and
Telecommunications (4)
Integration of object-oriented programming and emerging
telecommunication networks for interactive distributed learning.
Conceptual orientation, policy issues, and emphasizing
interactive instruction and training delivered over enterprise
and wide area networks. Special attention to the construction of
applications for satellite delivery, the Internet, and desktop-
conferencing systems. Prerequisite: EdT 404 or consent of
instructor.

EdT 433. Introduction to Instructional Design (3)
The systematic design of instruction. Emphasis on the use of
instructional design models, both behavioristic and cognitive, to
create effective instruction. Models and processes used in
education and industry. Design of instructional materials
employing models used in education and industry. Must be
taken with accompanying practicum in instructional design
(EdT 434).

EdT 434. Practicum in Instructional Design (1)
Technology-based activities to enhance instructional design
skills. Must be taken with EdT 433, Introduction to Instructional
Design.

EdT 443. Principles of Instructional Interface Design (3)
Design principles applied specifically to the creation of
technology-based instructional programs. Topics include
learner-versus program-control, interface consistency, principles
of screen layout, and attention-getting and retention-enhancing
techniques. Special emphasis on multimedia and graphical user
interfaces in education and training. Students design—but do
not code—technology-based lessons. Must be taken with
accompanying practicum in interface design (EdT 444).

EdT 444. Practicum in Interface Design (1)
Use of technology-based learning to acquire additional interface
design skills. Application of interface design skills to realistic
design projects. Must be taken with EdT 443, Principles of
Instructional Interface Design.

EdT 453. Advanced Instructional Design (3)
Advanced instructional design and interface issues. Design of
instructional environments, selection of instructional metaphors,
the impact of the interface on the user, and demands of
designing for newer learning technologies. Must be taken with
the accompanying advanced practicum in instructional design
(EdT 454). Prerequisite: EdT 433 or consent of instructor.

EdT 454. Advanced Practicum in Instructional Design (1)
Use of technology-based learning to acquire additional
instructional design skills. Application of instructional design
skills to realistic design projects. Must be taken with EdT
453, Advanced Instructional Design.

EdT 455. Vygotsky’s Theories Applied to Educational
Technology (3)
Advanced seminar examining historical and theoretical issues
related to Vygotsky’s theories of socio-historical psychology.
Vygotsky’s theories applied specifically to the design and use of
technology-based instructional materials.

EdT 458. Integrating Experience in Educational Technology (3-8)
Pursuit of independent topics of interest through directed
research, participation in internal or external project work or
internships, or development of portfolio materials. Individual or
team work under the direction of a faculty member. May be
repeated for up to 8 hours of credit. Prerequisites: Educ 403,

EdT 471. Evaluation of Technology-Based Instructional
Systems (3)
Examination of current issues and practices related to the design
and evaluation of instructional systems with special
consideration to the delivery and management of instruction
utilizing educational technology. A case study approach will be
used to study both instructional systems and the evaluation of
individual learning in technology-based curricula.

EdT 477. Research Topics in Educational Technology (3)
Current issues and practices related to the use or adoption of
educational technology. Topics will vary (for example, The Role
of Educational Technology in Teaching Persons with Special
Needs; Educational Technology in the Workplace; Educational
Technology and School Restructuring). May be repeated for
credit as topic varies.

Approaches and techniques applicable to empirical research
studies in educational technology, both quantitative and
qualitative. Students design and carry out small-scale investigations of research questions and hypotheses related to educational technology and write up research reports of their findings and conclusions. Prerequisite: Educ 403.

**School Psychology**

**SchP 402. Applied Behavior Analysis (3)**
Theory and application of behavior modification methods in classroom and clinical settings. Topics include behavior analysis, outcome research, task utilization, and single case research.

**SchP 404. Historical and Contemporary Issues in School Psychology (3)**
History of psychology, education, and school psychology. Roles and function of school psychologist; legal and ethical aspects of school psychology.

**SchP 412. Consultation Procedures (2)**
Observational methodology utilized in consultation; rationale, theory, and methods of consultation; individual, group, and parent consulting. Study of research on the consultation process. Students must also register for one credit of SchP 431.

**SchP 422. Assessment of Intelligence (3)**
Administration and interpretation of individual tests of intelligence used in school evaluation and preparation of psychological reports. Prerequisite: permission of instructor.

**SchP 423. Behavioral Assessment (3)**
Techniques of behavioral assessment including direct observation, interviews, checklists, rating scales, self-monitoring, and role-play tests. Prerequisite: permission of instructor.

**SchP 425. Assessment and Intervention in Educational Consultation (3)**
Collection and use of data in designing classroom interventions. Curriculum based assessment, direct behavioral assessment, and structured interviews, and the interrelationship with diagnoses are emphasized within the behavioral consultation model. Utilization of data from actual case studies. Prerequisites: SchP 402, SchP 423.

**SchP 426. Advanced School and Family Interventions (3)**
Overview of school-based and family-based intervention strategies for children and adolescents presenting interpersonal, emotional, developmental or behavioral challenges. Examples of topics covered include crisis intervention, peer-mediated interventions, self-management interventions, behavioral parent training, interventions for child abuse/neglect and computer-assisted instruction. Prerequisite: SchP 402 or permission of instructor.

**SchP 427. Standardized Tests, Measurement and Appraisal (3)**
Principles of psychological measurement (e.g., tests construction, technology, validity, reliability, functional utility). Ethical, legal, and cultural issues in the administration and interpretation of psychological tests. Case conceptualization, reporting and presentation.

**SchP 429. Special Topics in School Psychology (with subtitle) (1-3)**
Principles of psychological measurement (e.g., tests construction, technology, validity, reliability, functional utility). Ethical, legal, and cultural issues in the administration and interpretation of psychological tests. Case conceptualization, reporting and presentation. One-credit diagnostic laboratory is mandatory for counseling majors but optional for students from other programs. Lab covers diagnostic interviewing and systems for the identification and classification of behavioral and psychological disorders.

**SchP 431. Practicum in Consultation Procedures (1-3)**
Supervised experience in conducting school-based consultations. Co-requisite, SchP 412.

**SchP 432. Practicum in Assessment of Intelligence (1-3)**
Supervised experience in the administration and interpretation of intelligence tests. Co-requisite, SchP 422.

**SchP 433. Practicum in Behavioral Assessment (1-3)**
Supervised experience in conducting behavioral assessments in school settings. Co-requisite, SchP 423.

**SchP 434. (SpEd 434) Applied Research Practicum (1-3)**
Designing and conducting research projects in applied settings.

**SchP 435. Practicum in Assessment & Intervention in Educational Consultation (1-3)**

**SchP 436. Specialized Practicum in School Psychology (with subtitle) (1-3)**
Supervised field experience in school psychology with a specific population or setting. May be repeated for credit. Permission of instructor required.

**SchP 437. Advanced Child Psychopathology (3)**
Advanced training in the definition, classification, etiology, long-term outcome, and treatment of children and adolescents with various psychopathological disorders. Emphasis is placed upon the assessment and treatment of child and adolescent psychopathology in school settings. Prerequisites: admission to doctoral program or by permission of instructor.

**SchP 438. Health/Pediatric Psychology (3)**
Introduction to training in the definition, etiology and behavioral/academic characteristics of children and adolescents with medical disorders. Emphasis is placed on the assessment and treatment of educational and behavioral sequelae of medical disorders in both school and health settings. Prerequisites: admission to doctoral program in school psychology or permission of instructor.

**SchP 439. Comprehensive School Health Programs (3)**
Examination of school-wide programs designed to address health care needs of children and adolescents in school settings. Focus is on development of primary prevention and integration of educational, medical, social and community resources. Permission of instructor required.

**SchP 440. Applications of Pediatric School Psychology**
Focus on further development of students' knowledge and application of pediatric school psychology. The etiology and developmental course of pediatric medical conditions will be examined, emphasizing the impact on school, family and community environments. Prerequisite: SchP 438 or SchP 439 or permission of instructor.

**SchP 442. Doctoral Practicum in School Psychology (1-6)**
Field-based experience in providing psychological services in school and/or clinical settings. Prerequisite: admission to doctoral program. May be repeated for credit.

**SchP 443. Certification Internship (1-6)**
Full-time experience in clinical/educational settings. Student must complete a minimum of 1,200 clock hours under joint supervision of faculty and field supervisor. May be repeated for credit.
SchP 444. Doctoral Internship (1-6)
Full-time experience in clinical/educational settings. Student must complete a minimum of 1,500 clock hours under joint supervision of faculty and field supervisor. May be repeated for credit.

SchP 473. (CPsy 473) Advanced Research Methods in Applied Psychology (1-3)
For doctoral students in applied psychology. Issues and methods of research design, data collection and data analysis. Advanced discussion of quantitative, qualitative and single-case research design. Admission to the Ph.D. program in counseling psychology or school psychology or permission of the instructor.

SchP 496. Doctoral Seminar in School Psychology (with subtitle) (3)
Selected topics in school psychology (titles will vary) including professional issues, assessment and intervention in school settings, and supervision of school psychology services. May be repeated for credit. Prerequisite: admission to doctoral program.

Special Education

SpEd 330. Special Topics in Special Education: (with subtitle) (1-3)
Current issues in the education of individuals with special needs. Titles vary. May be repeated for credit as title varies.

SpEd 332. Education and Inclusion for Individuals with Special Needs (3)
Legal, educational and social issues related to the special education of individuals with mental retardation, physical disabilities, emotional/behavioral disorders, learning disabilities, visual and hearing impairments, health impairments and those who are intellectually gifted. Emphasis will be on meeting the diverse needs of students in general education classrooms and settings.

SpEd 333. Physical Handicaps and Developmental Disabilities (3)
Definition, classification, etiology, treatment and historical perspectives of individuals with mental retardation, autism, cerebral palsy, and other severe disabilities (e.g., deaf/blind). Remediation of movement difficulties, physical and occupational therapy interventions.

SpEd 338. (Psy 338) Emotional and Behavioral Disorders of Children (3)
Definition, classification, etiology, treatment, and historical perspective of children and adolescent disorders.

SpEd 339. Design of Instruction of Individuals with Learning Disabilities (3)
Issues related to the definition, etiology, assessment and service delivery in the field of learning disabilities. Characteristics and historical perspectives of individuals with learning disabilities. Remediation of learning and social problems through effective design of instruction.

SpEd 402. (SchP 402) Applied Behavior Analysis (3)
Theory and application of behavior modification methods in classroom and clinical settings. Topics include behavior analysis, outcome research, task utilization, and single case research.

SpEd 405. Assessment of Individuals with Mild Disabilities (3)
Educational assessment procedures used with individuals with special needs. Understanding and applying information from formal educational assessment and interviews. Utilization of curriculum based assessment.

SpEd 418. Life Skills and Transition Strategies (3)
Curriculum and methods for teaching skills of daily living and preparing students with disabilities for transition to adult living. Includes vocational training, community skills, home and daily living, self-care, leisure, communication and functional academics. Emphasis on transition planning for students with physical disabilities, emotional disturbance, learning disabilities, developmental disabilities, traumatic brain injury, autism, severe disabilities and related challenges.

SpEd 419. Academic and Curricular Strategies for Individuals with Disabilities (3)
Methods course designed to increase knowledge of instruction of reading, language arts, mathematics and content area skills. Emphasis on instructional design and strategies, evaluation of commercial textbooks and possible modifications needed for use with individuals with disabilities.

SpEd 420. Intern Teaching: Certification (3)
Competency-based practice in application of procedures for teaching a broad spectrum of individuals with special needs in preparation for Level I Certification as a Teacher of the Mentally or Physically Handicapped. Prerequisite: consent of program coordinator one semester before registering for the course.

SpEd 424. Assessment of Individuals with Severe Disabilities (3)
Curriculum-based assessment and program development for individuals whose disabilities preclude traditional academic or psychological assessment. Emphasis on life skills assessment.

SpEd 428. Positive Behavior Support (3)
The design of comprehensive, multicomponent behavior support plans for individuals with disabilities who engage in challenging behaviors. Topics include functional assessment strategies, antecedent and setting event interventions, alternative skill training, consequence strategies, lifestyle interventions and teaching strategies. Taught from a noncategorical perspective. Prerequisite: SpEd 402 or permission of the instructor.

SpEd 429. Professional Seminar (3)
Master's seminar on current issues in the area of special education and research design. Prerequisite is 18 graduate credits in special education.

SpEd 430. Advanced Seminar in Special Education (3)
Advanced issues relating to the field of special education. Titles will vary.

SpEd 432. Supervision of Special Education (3)
Advanced knowledge of teaching research with individuals with special needs. Teacher supervision models.

SpEd 434. (SchP 434) Applied Research Practicum (1-3)
Designing and conducting research projects in applied settings.

SpEd 435. Internship: Supervision of Special Education (3)
Advanced students receive competency-based practice in staff supervision in preparation for certification as a Supervisor of Special Education. Prerequisite: consent of program coordinator one semester before registering for the course.

SpEd 452. Assessment and Planning with Individuals with Disabilities (3)
Educational assessment procedures for individuals with special needs. Includes both academic and life skills assessment. Utilization of curriculum-based assessment. Involvement of the student and family in educational planning. Understanding and applying formal assessment and interviews. (Note: This course replaces SpEd 405 or SpEd 424 as a core requirement; however, both of these courses will continue to be offered as electives.)

SpEd 465. Advanced Methods for Inclusion (3)
Advanced techniques for educating students with disabilities in general education based on current research and practice.
Accommodations and planning for physical inclusion. Instructional inclusion through embedded instruction, adaptations, and curriculum overlapping. Decision hierarchies for level of instructional adaptation. Social inclusion methods through methods of social facilitation. Taught from a noncategorical perspective and addresses students with all levels of disability (e.g., mild and severe). Prerequisite: SpEd 332.

SpEd 490. Doctoral Seminar in Special Education (3) Advanced knowledge of issues and research in the education of individuals with special needs. Topics will vary. May be repeated for credit. Prerequisite: admitted for doctoral studies.

Educational Technology

See listings under Education.

Electrical Engineering and Computer Science

Professors. Bruce D. Fritchman, Ph.D. (Lehigh), chair; Frank H. Hielshcer, Ph.D. (Illinois) associate chair; Terrance E. Boult, Ph.D. (Columbia); Dragana Zbrakovic, Ph.D. (Florida); D. Richard Decker, Ph.D. (Lehigh), head of electrical engineering division; Douglas R. Frey, Ph.D. (Lehigh); Samuel L. Guldin, M.A. (Princeton); Miltiades Hatalis, Ph.D. (Carnegie Mellon); Donald J. Hillman, Ph.D. (Cambridge, England); Carl S. Holzinger, Ph.D. (Lehigh); James C. M. Hwang, Ph.D. (Cornell); Edwin J. Kay, Ph.D. (Lehigh), head of computer science division; Alastair D. McAulay, Ph.D. (Carnegie Mellon), Chandler-Weaver professor; Roger N. Nagel, Ph.D. (Maryland), Harvey E. Wagner professor of manufacturing systems engineering; Kenneth K. Tzeng, Ph.D. (Illinois); Marvin H. White, Ph.D. (Ohio State), Sherman Fairchild professor of electrical engineering.

Associate professors. Glenn D. Blank, Ph.D. (Wisconsin-Madison); Rick S. Blum, Ph.D. (Pennsylvania); Demetrios Christodoulides, Ph.D. (Johns Hopkins); Weiping Li, Ph.D. (Stanford); Karl H. Norean, Ph.D. (Imperial College, London); Patti T. Ota, Ph.D. (Pennsylvania), vice president; Meghan D. Wagh, Ph.D. (I.I.T., Bombay), head of computer engineering division.

Assistant professors. Eunice Santos, Ph.D. (Berkeley); Michael J. Schulte, Ph.D. (U. of Texas at Austin).


The department of electrical engineering and computer science (EECS) offers undergraduate and graduate programs of study along with supporting research for students interested in the fields of electrical engineering, computer engineering, and computer science. Lehigh University offers a bachelor of science degree from the P. C. Rossin College of Engineering and Applied Science in electrical engineering, computer engineering, and computer science, and it offers the bachelor of science degree, and the bachelor of arts degree with a major in computer science, from the College of Arts and Sciences. A minor in computer science is available except for students in the department.

Graduate study leads to the degrees master of science, master of engineering, and doctor of philosophy in electrical engineering, the master of science in computer engineering, and to the degrees master of science and doctor of philosophy in computer science.

While each of the programs has its unique attributes, Lehigh's programs exploit the growing interrelationship among electrical engineering, computer engineering, and computer science. For example, a new computer system which may encompass fundamental algorithmic development, innovative architecture and logic design, and very large scale integrated circuit design and fabrication requires the expertise of individuals knowledgeable across the spectrum.

The undergraduate programs emphasize the fundamental aspects of their respective areas. Engineering design concepts are introduced early in the curriculum, and required instructional laboratories introduce design as a hands-on activity. Electives permit the student to tailor a program according to his/her interests and goals, whether they be in preparation for graduate study or entry into industry. Students are free to select courses offered by other departments and are encouraged to do so when appropriate. In this way they can prepare themselves for activities which straddle departmental boundaries or for entry into professional schools such as medicine or management. Students have the opportunity to synthesize and apply their knowledge in a senior design project. Students may use the senior design project as a way to participate in the various research projects of the department.

The department maintains a number of laboratories in support of its curricular programs. These laboratories include the sophomore laboratory, junior electronics circuits laboratory, microcomputer laboratory, electromechanics laboratory, lightweight laboratory, digital signal processing laboratory, parallel computing laboratory, and the digital systems laboratory. The laboratory has research laboratories in artificial intelligence, computer architectures; design and computing systems; electron device physics; microelectronics fabrication; microwave monolithic circuits; microwave and very-large-scale integrated circuit design and fabrication requires the expertise of individuals knowledgeable across the spectrum.

The graduate programs allow students to deepen their professional knowledge, understanding, and capability within their subspecialties. The thesis is regarded as an essential and important ingredient of these programs. Each graduate student develops a program of study in consultation with his or her graduate advisor. Key research thrust areas in the department include:

1. Silicon and gallium arsenide microelectronics, VLSI architectures, optoelectronics.

2. Signal processing, optical data communication and networking, error-control coding.

3. Computer vision, object-oriented software, multimedia, AI and languages, parallel and distributed processing.

Graduate research is encouraged in these and other areas.

Computers and computer usage are an essential part of the student's environment. The university provides a distributed network of about 75 high-performance workstations and over 300 PC-compatible microcomputers in public sites throughout the campus. The EECS department has state-of-the-art systems to augment and extend the generally available university systems. The primary department resource is a network of more than 60 Sun workstations, file servers, and compute servers, running the Unix operating system. With over 60 gigabytes of storage, CD-ROM drives, tape drives, and accelerated graphics, these systems provide an array of software tools for our students and researchers including programming languages (C, C++, Pascal, FORTRAN, etc.), software development tools, hardware simulators, and electronic computer-aided design packages. In addition to the workstations, the department maintains a collection of PC-compatible microcomputers for EECS students, including a set of machines which can be dedicated to hardware/software projects. The department also provides various application-specific systems, including multimedia stations with sound and video capture and generation capabilities, Silicon Graphics workstations for image processing and visualization, and a 64-node multiprocessor transputer for parallel processing.
instruction and research. The workstations and microcomputers are connected via multiple high-speed ethernet, fiber optic, and ATM networks, which are in turn connected to the university's backbone network, and through multiple T1 connections to the Internet. Students are not required by the department nor the university to own a personal computer, but many find such a tool a valuable asset.

A detailed description of the curricular programs follows with a listing of the required courses and with a listing of the departmental course offerings. The departmental courses carry the prefixes CSc for computer science and ECE for electrical and computer engineering. The student is urged to search in both listings for courses appropriate to his/her career goal.

Undergraduate Programs

Mission Statement
Oversight of the undergraduate degree programs in the department is provided through the divisions of electrical engineering, computer engineering, and computer science. The mission of these divisions, consistent with those of the Department of Electrical Engineering and Computer Science and of the P.C. Rossin College of Engineering and Applied Science at Lehigh University, is to provide quality education, research, and service to our constituents. Major goals of the divisions are to:

1. Educate a new generation of engineers and scientists to meet the challenges of the future.
2. Promote a sense of scholarship, leadership and service among our graduates.
3. Create, develop, and disseminate new knowledge.
4. Provide national leadership to the electrical engineering, computer engineering, and computer science professions.

Bachelor of Science in Electrical Engineering
The required courses for this degree contain the fundamentals of linear circuits, systems and control theory, electronic circuits, signal theory, physical electronics, electromagnetic theory, energy conversion, digital systems, and computing techniques. A strong foundation in the physical sciences and in mathematics is required.

Approved electives, chosen with the advisor's consent, are selected in preparation for graduate study or entry into industry according to individual interests. The program totals 136 credit hours. The recommended sequence of courses follows:

See freshman year requirements, section III.

sophomore year, first semester (17 credit hours)
ECE 33  Introduction to Computer Engineering (4)
ECE 81  Principles of Electrical Engineering (4)
Phy 21, 22 Introductory Physics II and Laboratory II (5)
Math 23  Analytic Geometry and Calculus III (4)

sophomore year, second semester (18 credit hours)
ECE 62  Sophomore Laboratory (1)
ECE 108  Signals and Systems (4)
ECE 126  Fundamentals of Semiconductor Devices (3)
Math 205  Linear Methods (3)
Eco 1  Principles of Economics (4)

junior year, first semester (17 credit hours)
ECE 121  Electronic Circuits Laboratory (2)
ECE 123  Electronic Circuits (3)
ECE 202  Introduction to Electromagnetics (3)
Math 208  Complex Variables (3)
HSS elective (3)
free elective (3)

junior year, second semester (17 credit hours)
ECE 125  Circuits and Systems (3)
ECE 138  Digital Systems Laboratory (2)

ECE 203  Introduction to Electromagnetic Waves (3)
Math 231  Probability and Statistics (3)
approved technical elective* (3)
free elective (3)

senior year, first semester (18 credit hours)
ECE 111  Proseminar (1)
ECE 136  Electromechanics (3)
ECE 251  Senior Project I (2)
HSS elective (3)
approved technical electives* (6)
free elective (3)

senior year, second semester (18 credit hours)
approved technical electives* (12)
HSS elective (3)
free elective (3)

*Approved technical electives are subjects in the area of science and technology. Students must select a minimum of four courses from the following list, with a minimum of two courses in each of two technical areas described in this list. Students must also choose at least one engineering elective in either materials, mechanics, thermodynamics, fluid mechanics or physical chemistry, and at least one science elective in physics, chemistry or biology. For students interested in solid-state electronics, quantum mechanics is recommended for the science elective.

Approved Technical Electives for Electrical Engineering

Breadth Requirement: Minimum of 4 ECE or CSc elective courses.

Depth Requirement: Minimum of 2 courses in one of the technical areas described below.

A. Solid-State Circuits
ECE 308  Physics and Models of Electronic Devices (3)
ECE 332  Design of Linear Electronic Circuits (3)
ECE 333  Medical Electronics (3)
ECE 351  Microelectronics Technology (3)
ECE 355  Applied Integrated Circuits (3)
ECE 361  Introduction to VLSI Circuits (3)
ECE 362  Introduction to VLSI System Design (3)

B. Signal Processing and Communications
ECE 212  Control Theory (3)
ECE 340  Adaptive Signal Processing (3)
ECE 342  Communication Theory (3)
ECE 343  Digital Signal Processing (3)
ECE 344  Statistical Signal Processing (3)
ECE 345  Speech Synthesis and Recognition (3)
ECE 375  Computer Vision (3)
ECE 387  Digital Control (3)
ECE 389  Control Systems Laboratory (3)
ME 342  Control Systems (3)

C. Microwaves and Lightwaves
ECE 254  Microwave-Lightwave Laboratory (2)
ECE 346  Microwave Circuits and Techniques (3)
ECE 347  Introduction to Integrated Optics (3)
ECE 348  Lightwave Technology (3)
ECE 371  Optical Information Processing (3)
ECE 372  Optical Networks (3)

D. Computers
CSc ***  Any CSc course except CSc 11 or CSc 252
ECE 216  Software Engineering (3)
ECE 316  Microcomputer System Design (3)
ECE 319  Digital System Design (3)
ECE 320  Logic Design (3)
Bachelor of Science in Computer Science

Two degree programs are available to students through either the College of Arts and Sciences or the P. C. Rossin College of Engineering and Applied Science. The program offered by the P. C. Rossin College of Engineering and Applied Science is accredited by the Computer Science Accreditation Board, Inc. The two programs are identical in the fundamental requirements in mathematics and computer science, and the programs are appropriate for entry into management or industrial positions and for continued graduate study. The programs differ in that the students must fulfill the distribution requirements of the respective college. The result of this difference is that the Arts and Sciences program requires 127 credit hours whereas the P. C. Rossin College of Engineering and Applied Science program requires 135 credit hours. Students with interests in management, finance, data processing, and information handling may find the arts and science college program more appropriate and students with interests in engineering and science applications may find the engineering and applied science college program more appropriate.

The required courses for the degrees contain the fundamentals of discrete mathematics, structured programming, algorithms, computer architectures, compiler design, operating systems, and programming languages. A strong foundation in mathematics is required. The recommended sequence of courses is as follows:

College of Arts and Sciences

See the distribution requirements of the College of Arts and Sciences, section III.

Bachelor of Science in Computer Science

- **freshman year, first semester** (17 credit hours)
  - Engl 1 Composition and Literature (3)
  - Math 21 Analytic Geometry and Calculus I (4)
  - CSc 11 Introduction to Computing (4)
    - distribution (6)

- **freshman year, second semester** (17 credit hours)
  - Engl 2 Composition and Literature: Fiction, Drama, Poetry (3)
  - Math 22 Analytic Geometry and Calculus II (4)
  - Math 23 Analytic Geometry and Calculus III (4)
  - CSc 17 Introduction to Computer Engineering (4)
    - distribution (6)

- **sophomore year, first semester** (17 credit hours)
  - CSc 109 Systems Programming (3)
  - CSc 303 Operating System Design (3)
  - Math 205 Linear Methods (3)
    - approved technical electives* (3)
    - distribution (3)

- **sophomore year, second semester** (15 credit hours)
  - CSc 240 Design and Analysis of Algorithms (3)
  - ECE 201 Computer Architecture (3)
  - ECE 216 Software Engineering (3)
    - approved technical electives* (3)

*Approved technical electives are subjects in the area of science and technology. They are not restricted to offerings in the department of computer science and electrical engineering. One elective must be an engineering science elective from another department.
senior year, first semester (16 credit hours)
CSc 303 Operating System Design (3)
CSc 318 Automata & Formal Grammars (3)
ECE 111 Proseminar (1)
Math 230 Numerical Methods (3) or
Engr 250 Computer Modeling of Scientific &
   Engineering Systems (3)

senior year, second semester (15 credit hours)
CSc 302 Compiler Design (3)
approved technical electives* (9)
distribution (3)

*Approved technical electives are chosen by the student, with
the approval of the major advisor, to support the professional
objectives of the student. To satisfy the A&S college distribution
requirements, the approved elective choices must include a
science course with an attached laboratory.

** Hardware-oriented courses include ECE 81, ECE 316, ECE 138,
ECE 319, ECE 320, CSc 209, or any other hardware-oriented
course approved by the advisor.

P. C. Rossin College of Engineering and Applied Science

See freshman year requirements, section III.

sophomore year, first semester (17 credit hours)
Math 23 Analytic Geometry and Calculus III (4)
Phy 21, 22 Introductory Physics II and Laboratory (5)
CSc 17 Structured Programming and Data
   Structures (4)
ECE 33 Introduction to Computer Engineering (4)

sophomore year, second semester (16 credit hours)
CSc 109 Systems Programming (3)
CSc 262 Programming Languages (3)
Eco I Principles of Economics (4)
Math 205 Linear Methods (3)
approved technical elective **(3)

junior year, first semester (18 credit hours)
CSc 261 Discrete Structures (3)
Math 231 Probability and Statistics (3) or
Math 309 Theory of Probability (3)
HSS elective** (6)
free elective (3)
approved technical electives* (3)

junior year, second semester (18 credit hours)
CSc 340 Design and Analysis of Algorithms (3)
ECE 201 Computer Architecture (3)
ECE 216 Software Engineering (3)
HSS elective **(3)
approved technical elective* (3)
free elective (3)

senior year, first semester (18 credit hours)
CSc 303 Operating System Design (3)
CSc 318 Automata & Formal Grammars (3)
ECE 111 Proseminar (1)
ECE 251 Senior Project I (2)
Math 230 Numerical Methods (3) or
Engr 250 Computer Modeling of Scientific and
   Engineering Systems (3)
HSS elective **(3)
free elective (3)

senior year, second semester (17 credit hours)
CSc 302 Compiler Design (3)
HSS elective** (5)
approved technical elective* (9)

*Approved technical electives are chosen by the student, with
the approval of the major advisor, to support the professional
objectives of the student. One of these electives must be a
hardware-oriented elective. Hardware-oriented courses include
ECE 81, ECE 316, ECE 138, ECE 319, ECE 320, CSc 209, or any
other hardware-oriented course approved by the advisor.

Bachelor of Arts in Computer Science
This program of 121 credit hours is for students who desire a
strong liberal arts program with a concentration in computer
science. The program contains the fundamentals of computer
science which include discrete mathematics, structured
programming, data structures, programming languages,
computer organization, compiler design, and operating systems.
The recommended course sequence is as follows:

See the distribution requirements of the College of Arts and
Sciences, section III.

freshman year, first semester (14 credit hours)
Engl 1 Composition and Literature (3)
Math 21 Analytic Geometry and Calculus I (4)
CSc 11 Introduction to Computing (4)
distribution (3)

freshman year, second semester (14 credit hours)
Engl 2 Composition and Literature: Fiction, Drama,
   Poetry (3)
Math 22 Analytic Geometry and Calculus II (4)
CSc 17 Structured Programming and Data
   Structures (4)
distribution (3)

sophomore year, first semester (16 credit hours)
CSc 261 Discrete Structures (3) or
Math 243 Algebra (3)
ECE 33 Introduction to Computer Engineering (4)
distribution (9)

sophomore year, second semester (15 credit hours)
Math 43 BMSS Linear Algebra (3)
CSc 109 Systems Programming (3)
ECE 201 Computer Architecture (3)
distribution (6)

junior year, first semester (15 credit hours)
CSc 262 Programming Languages (3)
hardware-oriented elective* (3)
distribution (6)
free elective (3)

junior year, second semester (15 credit hours)
free elective or
hardware-oriented elective* (3)
distribution (6)
free elective (6)
senior year, first semester (16 credit hours)
CSc 303 Operating System Design (3)
CSc 318 Automata and Formal Grammars (3)
distribution (3)
free electives (7)

senior year, second semester (16 credit hours)
CSc 302 Compiler Design (3)
distribution (6)
free electives (7)

*The Junior year must contain at least one hardware-oriented elective course in one of the two semesters. Hardware-oriented courses include ECE 81, ECE 316, ECE 138, ECE 319, ECE 320, CSc 209, or any other hardware-oriented course approved by the advisor.

Minor in Computer Science
The minor in computer science provides a concentration which includes software development and programming, computer organization, and essential elements of computer science. This minor is not available to students of the department. The minor requires 18 credit hours, consisting of the following:

CSc 11 Introduction to Computing (4)
CSc 17 Structured Programming and Data Structures (4)
ECE 33 Introduction to Computer Engineering (4)

and two CS electives from the following list:

CSc 109 Systems Programming (3) or
CSc 241 Data Base Systems (3) or
CSc 261 Discrete Structures (3) or
CSc 271 Programming in C and the Unix Environment (3) or
CSc 262 Programming Languages (3) or
CSc 327 Artificial Intelligence Theory and Practice (3) or
CSc 340 Design and Analysis of Algorithms (3)

Graduate Programs
Graduate programs of study provide a balance between formal classroom instruction and research and are tailored to the individual student's professional goals. The programs appeal to individuals with backgrounds in electrical or computer engineering, computer or information science, mathematics, or the physical sciences. Research is an essential part of the graduate program. Major research areas include:

Compound Semiconductor Microwave & Quantum Electronics

Microelectronics - Devices, Integrated Circuits, VLSI Design
Silicon integrated circuit technology, processing, fabrication and testing. Semiconductor device physics, small geometry devices, CMOS VLSI logic design and verification, computer-aided design (CAD), VLSI chip architectures. Non-linear circuit design.

Information and Computer Engineering
Networking and distributed computing; architecture, distributed processing, error control, security and protection; real-time processing; pipelining and scheduling, signal processing algorithms, VLSI architectures, speech compression and recognition, concurrent processing, fault tolerant computing; hardware/software redundancy, coding theory; use of optics in fiber optic communications, networks, and computers.

Software and Artificial Intelligence
Expert systems; knowledge-based systems in design, electronics packaging, manufacturing, and construction; natural language processing; AI programming languages; learning systems and mechanisms; data models and object-oriented systems; user interfaces; decision-support systems; database interfaces; computer vision, including use of color and polarization, object-oriented software and parallel/distributed systems.

The master of science degree requires the completion of 30 credit hours of work which may include a six-credit-hours thesis for the E.E. and CompE. degrees and a three-credit-hour thesis for the C.S. degree. The C.S. degree requires CSc 302, Compiler Design, CSc 411, Advanced Programming Techniques, and CSc 403, Theory of Operating Systems. A program of study must be submitted in compliance with the graduate school regulations. An oral presentation of the thesis is required.

The master of engineering degree requires the completion of 30 credit hours of work, which includes design-oriented courses and an engineering project. A program of study must be submitted in compliance with the college rules. An oral presentation of the project is required.

The Ph.D. degree in electrical engineering and the Ph.D. degree in computer science require the completion of 42 credit hours of work (including the dissertation) beyond the master's degree (48 hours if the master's degree is non-Lehigh), the passing of a departmental qualifying examination appropriate to each degree within one year after entrance into the degree program, the passing of a general examination in the candidate's area of specialization, the admission into candidacy, and the writing and defense of a dissertation. Competence in a foreign language is not required.

Additional graduate program information may be obtained from the department's graduate coordinator.

Departmental Courses
Courses are listed under the prefixes CSc and ECE. Generally, electrical engineering courses carry the ECE prefix and computer science courses carry the CSc prefix. Computer engineering courses are found under either prefix. The reader should consult both listings.

Computer Science (CSc)

For Undergraduate Students
CSc 11. Introduction to Computing (4) fall
Problem solving and programming in C++. Survey of great ideas in computer science. Multi-media computer laboratory. No prerequisites. Blank. (ES 2) (ED 2)

CSc 17. Structured Programming and Data Structures (4) spring
Algorithmic design and implementation in a high-level, object-oriented language such as C++. Recursion, lexical programs, pointers, data structures, and their applications. Prerequisite: CSc 11 or Engr 1 or previous experience with programming. (ES 3), (ED 1)

CSc 109. Systems Programming (3) spring
Advanced data structures: hash tables, B-trees, disk files. Design of assemblers, macro-processors, loaders, interpreters, translators, communication protocols. Use of a high-level language to implement sample systems. Prerequisites: CSc 17 and ECE 33. (ES 1.5), (ED 1.5)

CSc 190. Special Topics (1-3)
Supervised reading and research. Prerequisite: consent of the division head.
CSc 209. Assembly Language Programming (3) fall
Design and development of assembly language programs for computer systems. Interactive input-output, handling interrupts, system architecture, hardware-software tradeoffs. Evaluation of program efficiency. Prerequisite: CSc 109. (ES 1), (ED 2)

CSc 241. Data Base Systems (3)
Data base concepts in terms of formal logic. Knowledge representation and deduction. Data base integrity. Query languages. Prerequisite: CSc 11 or approval of the division head. (ES 1.5), (ED 1.5)

CSc 252. Computers and Society (3)
A general nontechnical survey of the impact of computers on modern society. Special attention is given to the use of large-scale data banks and retrieval systems, the problems of privacy and file security, and the impact of automation on everyday life. (ES 0), (ED 0)

CSc 261. (Math 261) Discrete Structures (3) fall and spring
Topics in discrete structures chosen for their applicability to computer science and engineering. Sets, propositions, induction, recursion; combinatorics; binary relations and functions; ordering, lattices and Boolean algebra; graphs and trees; groups and homomorphisms. Various applications. Prerequisites: Math 21 and either CSc 11 or Engr 1. (ES 2), (ED 1)

CSc 262. Programming Languages (3) fall and spring
Use, structure and implementation of several programming languages. Prerequisite: CSc 17. (ES 1.5), (ED 1.5)

CSc 271. Programming in C and the Unix Environment (3)
C language syntax and structure. C programming techniques. Emphasis on structured design for medium to large programs. Unix operating system fundamentals. Unix utilities for program development, text processing, and communications. Prerequisite: CSc 17. (ES 1), (ED 2)

CSc 302. Compiler Design (3) spring
Principles of artificial language description and design. Sentence parsing techniques, including operator precedence, bounded-context, and syntax-directed recognizer schemes. The semantic problem as it relates to interpreters and compilers. Dynamic storage allocation, table grammars, code optimization, compiler-writing languages. Prerequisites: CSc 109 and CSc 318. (ES 1.5), (ED 1.5)

CSc 303. Operating System Design (3) fall
Assemblers, executive systems, multiprogramming, time sharing. Concurrent tasks, deadlocks, resource sharing. Construction of a small operating system. Prerequisites: ECE 201 and CSc 109 or ECE 216. (ES 1.5), (ED 1.5)

CSc 313. Computer Graphics (3)
General principles; algorithms; display devices and organization; methods of interaction; design of visual interactive systems. Prerequisite: CSc 109. (ES 1.5), (ED 1.5)

CSc 318. Automata and Formal Grammars (3) fall
Formal languages, finite automata, context-free grammars, Turing machines, complexity theory, undecidability. Prerequisite: CSc 261. (ES 3), (ED 0)

CSc 327. Artificial Intelligence Theory and Practice (3)
Survey of foundations: heuristic search, knowledge representation, general problem solvers, probabilistic reasoning, connectionism. Survey of applications and research issues, such as knowledge engineering, natural language processing, intelligent robots, cognitive science. Use of expert system and neural net software to develop rule-based and connectionist systems. (ES 2), (ED 1)

CSc 330. Advanced Software Engineering Tools (3)
CASE tools; portability and reusability of software; experimental methods in software engineering; automatic programming. Prerequisite: ECE 216. (ES 1), (ED 2)

CSc 332. Multimedia Design and Development (3)
Analysis, design and implementation of multimedia software, primarily for computer-based training. Projects emphasize user interface design, content design with storyboards or scripts, creation of graphics, animation, audio and video materials, and software development using high level authoring tools. Prerequisite: CSc 216 or consent of instructor. Blank. (ES 0), (ED 3)

CSc 340. (Math 340) Design and Analysis of Algorithms (3) spring
Algorithms for searching, sorting, counting, graph and tree manipulation, matrix multiplication, scheduling, pattern matching, fast Fourier transform. Minimum time and space requirements are established, leading to the notion of abstract complexity measures and the intrinsic complexity of algorithms and problems, in terms of asymptotic behavior. The question of the correctness of algorithms is also treated. Prerequisites: Math 22 and CSc 261 (Math 261). (ES 3), (ED 0)

CSc 350. Special Topics (3)
Selected topics in the field of computer science not included in other courses. May be repeated for credit.

CSc 365. Natural Language Processing (3)
Computer analysis of human languages, such as English. Syntactic parsing and semantic interpretation of sentences; morphological recognition of words and idioms. Applications of natural language processing such as database queries. Prerequisite: CSc 262 or equivalent familiarity with Prolog, Lisp. (ES 2), (ED 1)

CSc 368. Artificial Intelligence Programming (3)
The use of LISP and related languages to simulate intelligence on computers. Prerequisite: CSc 262 or approval of the division head. (ES 2), (ED 1)

CSc 373. Hardware & Software Topics in Parallel Computing (3)
Introduction to parallel computing, covering both hardware and software topics such as interconnection networks, SIMD, MIMD, and hybrid parallel architectures, parallel languages, parallelizing compiler techniques and operating systems for parallel computers. Prerequisite: ECE 201 and CSc 303 previously or concurrently, or consent of the instructor. (ES 1.5), (ED 1.5)

CSc 376. Parallel Algorithms (3)
Parallel algorithms for searching, sorting, matrix processing, network optimization, and selected graph problems. Implementation and efficiency measures of parallel algorithms also considered. Prerequisite: CSc 375 or CSc 340 or consent of instructor. (ES 1), (ED 2)

CSc 392. Independent Study (1-3)
An intensive study, with report, of a topic in computer science which is not treated in other courses. May be repeated for credit. Prerequisite: Consent of instructor.

For Graduate Students
CSc 403. Theory of Operating Systems (3)
Principles of operating systems with emphasis on hardware and software requirements and design methodologies for multiprogramming systems. Global topics include the related areas of process management, resource management, and file systems. Prerequisite: CSc 303 or equivalent.

CSc 409. Theory of Automata and Formal Grammars (3)
Finite automata. Pushdown automata. Relationship to definition and parsing of formal grammars. Prerequisite: CSc 318.
CSc 411. Advanced Programming Techniques (3) spring
Deeper study of structured programming, data structures, back­tracking, recursion. Applications of basic concepts of automata theory and formal language theory. Fundamental principles of "large program" design. Several major programming assignments using Pascal. Prerequisite: CSc 17 or consent of the division head. Gulden

CSc 412. Object-Oriented Programming (3)
Objects, messages, classes and inheritance, the model-view­controller paradigm. Prototyping the user interface. Kay

CSc 413. Robotics and Intelligent Machines (3)
Software aspects of robot and intelligent machine controls. Fundamental control issues through language and artificial intelligence implementations.

CSc 414. Expert Systems (3)

CSc 415. Database Topics (3)
Design issues in integrated database systems. Database entities and their relationships. Prerequisite: CSc 241 or equivalent.

CSc 416. Advanced Issues in Knowledge-Based Systems (3)
Advanced techniques and current applications of knowledge­based systems. Emphasis on knowledge engineering techniques through the development of a substantial system. Prerequisite: CSc 414. Hillman and Blank

CSc 417. Topics in Information Retrieval (3)
Selected topics in the design of advanced retrieval systems. Prerequisite: CSc 241 or equivalent.

CSc 418. Uncertainty in Knowledge-Based Systems (3)
Basic problems and possibilities for probable inference by expert systems are discussed. In this light, Bayesian inference, certainty factors, Dempster-Shafer evidence theory, and fuzzy logic are described and critiqued. Various related topics are also discussed.

CSc 422. Advanced Topics in Compiling (3)
Topics from general parsers, attributed translation, attribute grammars, two-level grammars, expression optimization, data flow, code optimization, compilers, implementation languages, multi-tasking languages. Prerequisite: CSc 302 or consent of the division head. Gulden

CSc 432. Object-Oriented Software Engineering (3)
Design and construction of modular, reusable, extensible and portable software using statically typed object-oriented programming languages (Eiffel, C++, Objective C). Abstract data types; genericity; multiple inheritance; use and design of software libraries; persistence and object-oriented databases; impact of object-oriented programming on the software life cycle.

CSc 437. Program Semantics (3)
Theories and techniques of program semantics and program verification. Topics may be chosen from denotational semantics, operational semantics, Floyd-Hoare semantics, temporal logic, dynamic logic, algebraic semantics, continuous semantics, recursive function theory or a current semantic theory. Gulden

CSc 440. Graph Theory and Application (3)
Fundamental concepts of and algorithms for graphs, including: connectivity, planarity, network flows, matchings, colorings, traversals, duality, intractability and applications. Prerequisite: CSc 340 or consent of instructor.

CSc 450. Special Topics (3)
Selected topics in computer science not included in other courses. May be repeated for credit.

CSc 463. Advanced Issues in Natural Language Processing (3)
Advanced techniques and current applications of natural language systems. Complex syntax and semantics, discourse coherence and planning, natural language interfaces and other applications. Prerequisite: CSc 365 or CSc 465. Blank

CSc 465. Seminar in Natural Language Processing (3)
Writing and presenting reviews of research issues in natural language, knowledge representation, speech processing and other applications. Requires concurrent attendance in CSc 365, Natural Language Processing.

CSc 491. Research Seminar (1-3)
Regular meetings focused on specific topics related to the research interests of department faculty. Current research will be discussed. Students may be required to present and review relevant publications. May be repeated for credit up to a maximum of three (3) credits. Prerequisite: Consent of instructor.

CSc 492. Independent Study (1-3)
An intensive study, with report of a topic in computer science which is not treated in other courses. May be repeated for credit. Prerequisite: Consent of instructor.

Electrical and Computer Engineering (ECE)

For Undergraduate Students

ECE 33. Introduction to Computer Engineering (4) fall
Analysis, design and implementation of small digital circuits. Boolean algebra. Minimization techniques, synchronous sequential circuit design, number systems and arithmetic. Microcomputer architecture and assembly level programming. Prerequisite: Engr 1 or CSc 17. (ES 2), (ED 2)

ECE 81. Principles of Electrical Engineering (4) fall and spring

ECE 82. Sophomore Lab (1) spring
An introduction to the fundamental laboratory instrumentation and measurement techniques of electrical and computer engineering. Five or six experiments based on the fundamental concepts discussed in the prerequisite courses. Introduction to PSPICE and application of various computer aids to design and documentation. Discussions of electrical components and laboratory safety. Use of an engineering notebook and report writing. One three-hour laboratory per week. Prerequisites: ECE 33 and ECE 81, previously. (ES 0), (ED 1)

ECE 108. Signals and Systems (4) spring
Continuous and discrete signal and system descriptions using signal space and transform representations. Includes Fourier series, continuous and discrete Fourier transforms, Laplace transforms, and z-transforms. Introduction to sampling. Prerequisite: ECE 81. (ES 4), (ED 0)

ECE 111. Proseminar (1) fall
A weekly seminar to acquaint students with current topics in electrical and computer engineering. Students prepare and present oral and written reports that are judged on quality and presentation as well as technical content. Prerequisite: senior standing. (ES 0.5), (ED 0.5)
ECE 121. Electronic Circuits Laboratory (2) fall
One lecture and one laboratory per week. Experiments illustrating the principles of operation of electronic devices and their circuit applications. Basic electronic instrumentation and measurement techniques. Corequisite: ECE 123. (ES 0.5), (ED 1.5)

ECE 122. Electronic Circuits (3) fall
Methods for analyzing and designing circuits containing electronic devices. Topics include device models, basic amplifier configurations, operating point stabilization, frequency response analysis, and computer-aided analysis of active circuits. Prerequisite: ECE 108. (ES 1.5), (ED 1.5)

ECE 125. Circuits and Systems (3) spring
Formulation of linear circuit equations in the time and frequency domain. Complete solutions of difference and differential equations. Network theorems. Basic stability and feedback concepts. Modulation theory, sampling theory and basic digital signal processing ideas. Prerequisite: ECE 108. (ES 2.5), (ED 0.5)

ECE 126. Fundamentals of Semiconductor Devices (3) spring
Introduction to the physics of semiconductors in terms of atomic bonding and electron energy bands in solids. Charge carriers in semiconductors and carrier concentration at thermal equilibrium. Principles of electron and hole transport, drift of diffusion currents, generation and recombination processes, continuity. Treatment of semiconductor devices including p-n junctions, bipolar junction transistors and field effect transistors. Prerequisite ECE 81. (ES 2.5), (ED 0.5)

ECE 136. Electromechanics (3) fall
Two lectures and one laboratory per week. An experimental introduction to electromechanical energy conversion. Basic concepts of magnetic fields and forces and their application to electrical apparatus including electromagnetic transducers, transformers, AC and DC machines. Prerequisite: ECE 81. (ES 2), (ED 1)

ECE 138. Digital Systems Laboratory (2) spring
Implementation issues and techniques for digital logic design. Combinational and sequential logic design using standard integrated circuits. I/O and interrupt processing. Design and implementation of real-time complex digital logic using microprocessor systems. Prerequisite: ECE 33. (ES 0.5), (ED 1.5)

ECE 162. Electrical Laboratory (1) spring
Experiments on circuits, machines, and electronic devices. Elementary network theory. Survey laboratory for students not majoring in electrical or computer engineering. Prerequisite: ECE 81. (ES 1), (ED 0)

ECE 201. Computer Architecture (3) spring
Structure and function of digital computers. Computer components and their operations. Computer interconnection structures. Memory system and cache memory. Interrupt driven input/output and direct memory access. Instruction sets and addressing modes. Instruction pipeline. Floating-point representation and arithmetic. Alternative architectures: RISC vs. CISC and introduction to parallel architectures. Prerequisite: ECE 33. (ES 1.5), (ED 1.5)

ECE 202. Introduction to Electromagnetics (3) fall
Elements of vector analysis, Coulomb's law, Biot-Savart's and Ampere's laws, Lorentz Forces, Laplace's, and Maxwell's equations, boundary conditions, methods of solution in static electric and magnetic fields, including finite element numerical approach. Quasistationary fields, inductance. Prerequisites: Math 205, Phys. 21. (ES 3), (ED 0)

ECE 203. Introduction to Electromagnetic Waves (3) spring
Uniform plane waves in free space and in materials, skin effect. Waves in transmission lines and waveguides, including optical fibers. Energy and power flow, Poynting's theorem. Reflection and refraction. Resonators. Radiation and diffraction. Prerequisite: ECE 202. (ES 2.5), (ED 0.5)

ECE 212. Control Theory (3) spring

ECE 216. Software Engineering (3) spring
The software life-cycle, life-cycle models, software planning, testing, specification methods, maintenance. Emphasis on team work and large-scale software systems, including oral presentations and written reports. Prerequisite: CSc 17 and CSc 262. (ES 1.5), (ED 1.5)

ECE 251. Senior Project I (2) fall
This capstone course integrates the knowledge and experience acquired in previous and concurrent courses. Emphasis is on design, implementation, test and evaluation of an engineering project in any of the diverse areas of electrical and computer engineering and computer science consistent with the abilities of the student and departmental resources. A written project proposal, periodic progress reports, a final project report, and a project demonstration are required. Prerequisite: Senior standing. (ES 0.5), (ED 1.5)

ECE 252. Senior Project II (2) spring
Same as ECE 251. May be used to substitute for ECE 251 for those students not following the normal schedule. Also serves as a continuation for those projects beyond the scope of a one-semester course. Two three-hour sessions per week. Prerequisite: Senior standing. (ES 0.5), (ED 1.5)

ECE 254. Microwave-Lightwave Laboratory (2)
Basic microwave and optical measurement techniques, design procedures and practical concepts. Practical aspects of fiber optics, optical transmission and modulation. Two three-hour sessions per week. Corequisite: ECE 346. (ES 1), (ED 1)

ECE 256. Honors Project (1) spring
Open by invitation only to students who have completed ECE 251, Senior Project. Selection is based upon the quality of the senior project with regard to ingenuity, design approach and completeness. The objective of this course is to carry the successful senior projects forward to completion of a technical paper suitable for publication or submission to a technical conference. A written paper and oral presentation are required by mid-semester. Oral presentations will be made before an appropriate public forum. Enrollment limited. (ES 0), ED 0

ECE 308. Physics and Models of Electronic Devices (3)
Physics of metal-semiconductor junction, p-n junctions, and MOS capacitors. Models of Schottky barrier and p-n junction diodes, JFET, MOSFET, and bipolar transistors. Prerequisite: ECE 126. (ES 2), (ED 1)

ECE 316. Microcomputer System Design (3) spring
Content is primarily hardware-oriented, but software issues are covered where required. Includes performance characteristics of the more popular devices on the market today. Specific topics include: basic microcomputer structure, bus interconnections, memory systems, serial and parallel interfacing, CRT controllers, interrupt structures, DMA. Prerequisite: ECE 33. Holzinger. (ES 0.5), (ED 2.5)

ECE 319. Digital System Design (3) fall
Design techniques at the register transfer level. Control strategies for hardware architectures. Implementation of
microprogramming, intersystem communication and peripheral interfacing. Hardware design languages and their use in design specification, verification and simulation. Prerequisite: ECE 138. (ES 0), (ED 3)

ECE 320. Logic Design (3)
Review of basic switching theory, vector boolean algebra, canonical implementations of medium-size circuits, threshold logic, fault detection in combinational and sequential logic, Multivalued and Fuzzy logic, regular expressions, nondeterministic sequential machines. Prerequisite: ECE 33. (ES 1.5), (ED 1.5)

ECE 332. Design of Linear Electronic Circuits (3)
Introduction to a variety of linear design concepts and topologies, with contemporary audio networks providing many of the concrete examples. Topics include low- and high-level preamps; equalizers and filters; mixers; voltage-controlled amplifiers; input and output stage modifications; power amplifiers; analog switching and digital interface circuitry. Prerequisites: ECE 123 and ECE 125. Frey. (ES 1), (ED 2)

ECE 333. Medical Electronics (3)
Bioelectric events and electrical methods used to study and influence them in medicine, electrically excitable membranes, action potentials, electrical activity of muscle, the heart and brain, biomaterials, pulse circuits and their applications. Prerequisite: ECE 123 or equivalent. Norian. (ES 2.5), (ED 0.5)

ECE 340. Adaptive Signal Processing (3)
Introduction to the uses and practice of modern adaptive signal processing. Theory and design of discrete-time optimum linear filters and adaptive filters. AR, MA, and ARMA processes are introduced. Common adaptive filtering algorithms are derived and discussed for transversal and ladder structures, including, LMS, Least Squares, and RLS algorithms. Kalman filtering is introduced with some applications. Some programming will be required, using preferably Maple or Matlab. Prerequisites: ECE 125 and Math 231 or Math 309. Frey. (ES 2.5), (ED 0.5)

ECE 342. Communication Theory (3)
Theory and application of analog and digital modulation. Sampling theory with application to analog-to-digital and digital-to-analog conversion techniques. Time and frequency division multiplexing. Introduction to random processes including filtering and noise problems. Introduction to statistical communication theory with primary emphasis on optimum receiver principles. Prerequisites: ECE 125 and Math 309 or Math 231. (ES 2.5), (ED 0.5)

ECE 343. Digital Signal Processing (3)
Study of orthogonal signal expansions and their discrete representations, including the Discrete Fourier Transform and Walsh-Hadamard Transform. Development of fast algorithms to compute these, with applications to speech processing and communication. Introduction to the z-transform representation of numerical sequences with applications to input/output analysis of discrete systems and the design of digital filters. Analysis of the internal behavior of discrete systems using state variables for the study of stability, observability and controllability. Prerequisite: ECE 108. (ES 2.5), (ED 0.5)

ECE 344. Statistical Signal Processing (3)
Introduction to random processes, covariance and spectral density, time average, stationarity, and ergodicity. Response of systems to random inputs. Sampling and quantization of random signals. Optimum filtering, estimation, and hypothesis testing. Prerequisite: Math 231 or Math 309, and ECE 108. Blum. (ES 2.5), (ED 0.5)

ECE 345. Speech Synthesis and Recognition (3)
Application of digital technology to generation and recognition of speech by machines. The analytical tools required for digitizing and encoding speech signals; the methods currently used for synthesizing and recognizing speech; various hardware products available to perform these tasks. Prerequisite: ECE 108. Holzinger. (ES 1), (ED 2)

ECE 346. Microwave Circuits and Techniques (3)

ECE 347. Introduction to Integrated Optics (3)
Theory of dielectric waveguides (ray and wave approach). Modes in planar slab optical guides and in waveguides with graded index profiles. Coupled-mode formalism and periodic structures. Coupling of optical beams to planar structures. Switching and modulation of light in dielectric guides: phase, frequency and polarization modulators; electro-optic, acoustooptic and magneto-optic modulators. Semiconductor lasers. Fabrication of semiconductor components. Recent advances. Prerequisites: ECE 202 and ECE 203. Christodoulides. (ES 3), (ED 0)

ECE 348. Lightwave Technology (3)
Overview of optical fiber communications. Optical fibers, structures and waveguiding fundamentals. Signal degradation in fibers arising from attenuation, intramodal and intermodal dispersion. Optical sources, semiconductor lasers and LEDs. Rate equations and frequency characteristics of a semiconductor laser. Coupling efficiency of laser diodes and LEDs to single-mode and multimode fibers. PIN and avalanche photodetectors. Optical receiver design. Transmission link analysis. Prerequisite: ECE 203. Christodoulides. (ES 2), (ED 1)

ECE 350. Special Topics (3)
Selected topics in the field of electrical and computer engineering not included in other courses. May be repeated for credit.

ECE 351. Microelectronics Technology (3)
Technology of semiconductor devices and of integrated circuits, including crystal growth and doping, phase diagrams, diffusion, epitaxy, thermal oxidation and oxide masking, lithography. The major emphasis will be on silicon technology, with additional lectures on GaAs technology. Prerequisites: ECE 126 and Phys 31. (ES 2), (ED 1)

ECE 355. Applied Integrated Circuits (3)
Emphasis on understanding of terminal characteristics of integrated circuits with excursion into internal structure only as necessary to assure proper utilization in system design. Classes of devices studied include operational amplifiers, digital-to-analog and analog-to-digital converters, linear multiplications, modulators, and phase-locked loops. Prerequisites: ECE 108 and 123. Holzinger. (ES 0.5), (ED 2.5)

ECE 361. Introduction to VLSI Circuits (3)
The design of Very Large Scale Integrated (VLSI) Circuits, with emphasis on CMOS Standard Cell design. Topics include MOS transistor physics, device behavior and device modeling, MOS technology and physical layout, design of combinational and sequential circuits, static and dynamic memories, and VLSI chip organization. The course includes a design project using CAE tools for layout, design rule checking, parameter extraction, and SPICE simulations for performance prediction. Two one-hour lectures and three hours of laboratory per week. Prerequisite: ECE 123. Hielscher. (ES 1.5), (ED 1.5)
ECE 362. Introduction to VLSI System Design (3)
Structured hierarchical approach to the design of digital VLSI circuits and systems. Use of CAE tools for design and verification. Topics include: systems aspects of VLSI design, design methodologies, schematic capture, functional verification, timing simulation, use of a CMOS standard cell library and of a silicon compiler. The course includes a semester-long design project, with the design to be fabricated by a foundry. Two one-hour lectures and three hours of design laboratory per week. Prerequisite: ECE 138. Hielscher. (ES 0.5), (ED 2.5)

ECE 371. Optical Information Processing (3)
Introduction to optical information processing and applications. Interference and diffraction of optical waves. 2D optical matched filters that use lenses for Fourier transforms. Methods and devices for modulating light beams for information processing, communications, and optical computing. Construction and application of holograms for optical memory and interconnections. Prerequisite: ECE 108. McAulay. (ES 2.5), (ED 0.5)

ECE 372. Optical Networks (3)
Study the design of optical fiber local, metropolitan, and wide area networks. Topics include: passive and active photonic components for optical switching, tuning, modulation and amplification; optical interconnection switches and buffering; hardware and software architectures for packet switching and wavelength division multiplexing systems. The class is supported with a laboratory. Prerequisite: ECE 81. McAulay. (ES 2), (ED 1)

ECE 375. Computer Vision (3)
Acquisition and processing of digital images. Interpretation of vision modalities. Intermediate level vision, including segmentation, texture, and shape representation. Three-dimensional scene understanding from stereo, texture, shading and photometric stereo. Basics of high level vision. Prerequisite: ECE 108 or equivalent or consent of instructor. Brzakovic. (ES 2), (ED 1)

ECE 387. (ChE 387, ME 387) Digital Control (3)
Sampled-data systems; z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Liapunov stability; state feedback control. Prerequisite: ChE 386 or ECE 212 or ME 342 or consent of instructor. (ES 3), (ED 0)

ECE 389. (ChE 389, ME 389) Control Systems Laboratory (2)
Experiments on a variety of mechanical, electrical and chemical dynamic control systems. Exposure to state-of-the art control instrumentation: sensors, transmitters, control valves, analog and digital controllers. Emphasis on comparison of theoretical computer simulation predictions with actual experimental data. Lab teams will be interdisciplinary. Prerequisites: ChE 386, ME 343, ECE 212. (ES 1), (ED 1)

ECE 392. Independent Study (1-3)
An intensive study, with report of a topic in electrical and computer engineering which is not treated in other courses. May be repeated for credit. Prerequisite: Consent of instructor.

For Graduate Students

ECE 401. Advanced Computer Architecture (3)
Design, analysis and performance of computer architectures; high-speed memory systems; cache design and analysis; modeling cache performance; principle of pipeline processing, performance of pipelined computers; scheduling and control of a pipeline; classification of parallel architectures; systolic and data flow architectures; multiprocessor performance; multiprocessor interconnections and cache coherence. Prerequisite: ECE 201 or equivalent.

ECE 402. Advanced Electromagnetics (3)

ECE 404. Computer Networks (3)
Study of architecture and protocols of computer networks. The ISO model; network topology; data-communication principles, including circuit switching, packet switching and error control techniques; sliding window protocols, protocol analysis and verification; routing and flow control; local area networks; network interconnection; topics in security and privacy.

ECE 407. Linear and Nonlinear Optics (3)
Diffraction theory, Gaussian beams. Optical resonators and waveguides. Crystal optics, second harmonic generation, parametric amplification. Third order nonlinearities and associated phenomena such as phase conjugation, optical bistability, self-focusing, optical switching, solutions, etc. Photorefractive effect. Brillouin and Raman scattering. Christodoulides

ECE 410. Digital Communication Systems (3)
Unified description of digital communication systems based on signal space concepts. Analysis of system performance in the presence of channel noise and bandwidth limitations. Comparison of many different types of digital-modulation techniques, combined with error correction, against theoretical limits. Both bandpass and baseband systems are considered. Optimum methods of detection are considered for all systems. Suboptimum techniques such as adaptive equalization are considered for baseband systems. Basic spread-spectrum concepts are introduced. Prerequisites: ECE 108 and either Math 231 or Math 309, or equivalents.

ECE 411. Information Theory (3)
Introduction to information theory. Topics covered include: development of information measures for discrete and continuous spaces study of discrete-stochastic information courses, derivation of noiseless coding theorems, investigation of discrete and continuous memoryless channels, development of noisy channel coding theorems. Fujimats

ECE 412. Advanced Digital Signal Processing (3)
Design and analysis of signal processing algorithms, number theoretic foundations of algorithm design, bilinear algorithms, computational techniques for digital filtering and convolution, Fourier transform and its algorithms, number theoretic transforms and applications to digital filtering, general and special purpose signal processor designs, application specific techniques in signal processing. Prerequisite: ECE 343 or consent of the department chairman. Wagh

ECE 414. Signal Detection and Estimation (3)
Brief review of probability and random process theory. Hypothesis Testing as applied to signal detection. Various optimality criterion including Bayes and Neyman-Pearson and their applications in digital communications, radar, and sonar systems. Optimum and locally optimum detection schemes for Gaussian and non-Gaussian noise. Estimation of unknown signal parameters. Topics of current interest including, distributed signal detection, robust signal detections and quantization for detection as time permits. Prerequisites: ECE 108, and Math 231 or Math 309. Blum
ECE 415. Numerical Processors (3)
Design strategies for numerical processors, cellular array adders and multipliers, conditional sum and carry-save asynchronous processors, data recording and Booth’s algorithms, use of alternate numerical bases, CORIDC trigonometric calculator, accumulator orientations, bit slice and bit-sequential processors, pipelining and parallel processing considerations. Prerequisite: ECE 201. Waghi

ECE 416. VLSI Signal Processing (3)
The fundamentals of performance-driven VLSI systems for signal processing. Analysis of signal processing algorithms and architectures in terms of VLSI implementation. VLSI design methodology. Includes a design project which requires use of a set of tools installed on SUN workstations for behavioral simulation, structural simulation, circuit simulation, layout, functional simulation, timing and critical path analysis, functional testing, and performance measurement. Prerequisite: ECE 361, ECE 343, or equivalent. Brzakovic

ECE 417. Pattern Recognition (3)

ECE 420. Advanced Circuits and Systems (3)
Review of the fundamentals of Circuits and Systems theory, including the time and frequency domain response of linear time-invariant circuits. Equation formulation for general lumped circuits, including node voltage and loop current analysis. Basic graph theoretic properties of circuits including Tellegen’s Theorem. Discussion of passivity and reciprocity including multiport network properties. State space formulation and solution of general circuits (and systems). Modern filter concepts, including synthesis techniques for active filters and externally linear filters, such as Log Domain filters. Techniques for the analysis of weakly nonlinear systems, as time permits. Prerequisites: Graduate standing, ECE 125 or equivalent.

ECE 423. Digital Image Processing (3)
Fundamentals of imaging acquisition and geometry. Fourier, Hadamard, Walsh and Wavelet Transforms and their usage in image segmentation and understanding. High-pass and low-pass filtering in frequency and spatial domains. Multiresolution analysis and spatial scale filtering. Shape and texture representation and recognition. Prerequisite: ECE 343 or equivalent. Brzakovic

ECE 424. Advanced Circuits and Systems (3)
Review of linear circuit and system analysis including time domain and frequency domain solution techniques. Overview of contemporary mathematical and circuit-theoretic techniques applied to the solution of linear circuits-including, fundamental loop and cutset equations, generalized nodal, modified nodal, tableau, and mesh equation formulation, hybrid N-port network description and state equation formulation, and selected matrix and linear operator theory relevant to the solution of system equations. Discretization and computer-based circuit analysis will be a fundamental theme of the course. Nonlinear and time varying networks will be discussed in this context. Frey

ECE 431. Topics in Switching Theory (3)
Emphasis on structural concepts motivated by recent advances in integrated circuit technology. Major topics include: logical completeness, decomposition techniques, synthesis with assumed network forms, systolic architectures, systolic lemma and its applications, bit serial architectures. Prerequisite: ECE 320 or equivalent. Waghi

ECE 433. (ChE 433, ME 433) State Space Control (3)
State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin’s Maximum Principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal open loop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: ME 343 or ECE 212 or ChE 386 or consent of instructor.

ECE 434. (ChE 434, ME 434) Multivariable Process Control (3)
A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feed forward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 435. Error-Correcting Codes (3)
Error-correcting codes for digital computer and communication systems. Review of modern algebra concentrating on groups and finite fields. Structure and properties of linear and cyclic codes for random or burst error correction covering Hamming, Golay, Reed-Muller, BCH and Reed-Solomon codes. Decoding algorithms and implementation of decoders. Prerequisite: CSc 261 or equivalent. Tzeng

ECE 436. (ChE 436, ME 436) Systems Identification (3)
The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasilinearization and invariant-imbedding techniques for nonlinear system parameter identification included. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 437. (ChE 437, ME 437) Stochastic Control (3)
Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gaussian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 447. Nonlinear Phenomena (3)
Investigation of nonlinear effects in active and passive lumped and distributed circuits with emphasis on methods of analysis as well as physical understanding of jump phenomena, van der Pol’s theory, stability criteria, phase locking. Transmission line and optical waves in nonlinear media; shock waves, harmonic generation and optical parametric amplification.

ECE 450. Special Topics (3)
Selected topics in electrical and computer engineering not covered in other courses. May be repeated for credit.

ECE 451. Physics of Semiconductor Devices (3)
Crystal structure and space lattices, crystal binding, lattice waves and vibrations, electrons and atoms in crystal lattices. Quantum mechanics and energy band theory, carrier statistics, Boltzmann transport theory, interaction of carriers with scattering centers,
ECE 452. Advanced Semiconductor Diode and Transport Theory (3)
Properties of metal-semiconductor contacts, Schottky barriers, ohmic contacts, hot electrons, intervalley scattering, velocity saturation, secondary ionization, avalanche breakdown. Applications to microwave devices such as avalanche and Gunn diodes, Schottky barrier diodes, tunnel diodes and PIN diodes. Prerequisite: ECE 451. Decker

ECE 455. Theory of Metal Semiconductor and Heterojunction Transistors (3)

ECE 460. Engineering Project (3-6)
Project work in an area of student and faculty interest. Selection and direction of the project may involve interaction with industry. Prerequisite: consent of department chairperson.

ECE 461. Theory of Electrical Noise (3)

ECE 463. Design of Microwave Solid State Circuits (3)
Equivalent circuit modeling and characterization of microwave semiconductor devices, principles of impedance matching, noise properties and circuit interaction, introduction to the design of high power and non-linear circuits. Decker

ECE 467. Semiconductor Material and Device Characterization (3)
This course covers the main characterization techniques used in the semiconductor industry. Emphasis is given to the electrical characterization methods although some optical, and physical analytical techniques are reviewed. The principles and the experimental set up for measuring the following parameters are covered: resistivity; carrier and doping concentration; contact resistance and Schottky barrier height; device series resistance; MOSFET's channel length and threshold voltage; carrier mobility; oxide and interface trapped charge; and carrier lifetime. Laboratory sessions provide hands-on experience on some of the above methods. Prerequisites: ECE 126 and ECE 308, or equivalent. Hatalis

ECE 469. Process Modeling for Semiconductor Devices (3)
Students will design and "manufacture" a Si or GaAs transistor through process simulation of ion implantation, epitaxial growth, diffusion and contact formation, etc. I-V characteristics and small signal parameters, suitable for digital and microwave circuit simulation programs, will be derived. Complementary to ECE 463 and 471. Prerequisite: ECE 308 or 351. Hwang

ECE 474. Analog CMOS VLSI Design (3)
The fundamentals of analog circuit design with CMOS linear IC techniques. Discrete Analog Signal Processing (DASP) is accomplished with switched-capacitor CMOS circuits. Analog building blocks include operational amplifiers, S/H circuits, comparators and voltage references, oscillators, filters, modulators, phase detectors/shifters, charge transfer devices, etc. Analog sub-system applications are phase-locked loops (PLL's), A/D and D/A converters, modems, sensors, adaptive filters and equalizers, etc. The emphasis is on the physical operation of analog CMOS integration circuits and the design process. Prerequisite: ECE 355 or equivalent. White

ECE 476. Analysis and Design of Analog Integrated Circuits (3)
Device and circuit models of bipolar and field effect transistors, bipolar and MOS integrated circuit technology, passive components, parasitic and distributed elements, amplifier gain stages, subthreshold gain stages, current sources and active load, temperature and supply independent biasing, output stage design, frequency response and slew rate limitation, operational amplifier and analog multiplier design. Circuit simulation using SPICE. Prerequisite: ECE 308 or equivalent. Hielscher

Large signal models and transient behavior of MOS and bipolar transistors. Basic inverter and logic gate circuits. Noise margins, operating speed, and power consumption of various logic families, including MOS, CMOS, saturated logic TTL, ECL, and IIL. Regenerative logic circuits and digital memories. Circuit design and computer-aided circuit analysis for LSI and VLSI circuits. Prerequisite: ECE 308 or equivalent. Hielscher

ECE 479. Advanced MOS VLSI Design (3)
The design of very large scale NMOS and CMOS integrated circuits. Strong emphasis on device physics, and on novel circuit design approaches for VLSI implementation. Examination of second-order effects involved in designing high performance MOS digital integrated circuits, with the goal of pushing the design process to the limits determined by our current understanding of semiconductor device physics and of the currently available technologies. The topics include device physics (subthreshold conduction, short channel effects), important circuit innovations (substrate bias generators, sense amplifiers), systems aspects (clocking, timing, array structures), as well as static and dynamic circuit implementations. Design project, using VLSI design automation tools. Prerequisites: ECE 308 (or equivalent) and ECE 361. Hielscher

ECE 483. Advanced Semiconductor Devices for VLSI Circuits (3)
Theory of small geometry devices for VLSI circuits. Emphasis of MOS bipolar device static and dynamic electrical characteristics. Carrier injection, transport, storage, and detection in bulk and interfacial regions. Limitations of physical scaling theory for VLSI submicron device structures. MOS physics and technology, test pattern device structures, charge-coupled devices, MNOS nonvolatile memory devices, and measurement techniques for device and process characterization. The influence of defects on device electrical properties. Prerequisite: ECE 451. White

ECE 485. Heterojunction Materials and Devices (3)
Material properties of compound semiconductor heterojunctions, quantum wells and superlattices. Strained layer epitaxy and band-gap engineering. Theory and performance of novel devices such as quantum well lasers, resonant tunneling diodes, high electron mobility transistors, and heterojunction bipolar transistors. Complementary to ECE 452. Prerequisite: ECE 451. Hwang

ECE 486. Integrated Solid-State Sensors (3)
The physical operation of sensor-based, custom integrated circuits. Emphasis on the integration of sensors, analog, and digital circuits on a silicon chip with CMOS technology. Sensors include photocells, electrochemical transducers, strain gauges, temperature detectors, vibration and velocity sensors, etc. Analysis of sensor-circuit performance limits including signal-to-noise, frequency response, temperature sensitivity, etc. Examples of sensor-based, custom IC's are discussed and analyzed with CAD modeling and layout. Prerequisite: ECE 451. White
ECE 491. Research Seminar (1-3)
Regular meetings focused on specific topics related to the research interests of department faculty. Current research will be discussed. Students may be required to present and review relevant publications. May be repeated for credit up to a maximum of three (3) credits. Prerequisite: Consent of instructor.

ECE 492. Independent Study (1-3)
An intensive study, with report, of a topic in electrical and computer engineering which is not treated in other courses. May be repeated for credit. Prerequisite: Consent of instructor.

ECE 493. Solid-State Electronics Seminar (3)
Discussion of current topics in solid-state electronics. Topics selected depend upon the interests of the staff and students and are allied to the research programs of the Sherman Fairchild Laboratory for Solid State Studies. Student participation via presentation of current research papers and experimental work. Prerequisite: consent of instructor. May be repeated for credit.

### Electrical Engineering

See listings under Electrical Engineering and Computer Science.

### Electrical Engineering and Engineering Physics

This dual-degree curriculum is particularly well-suited for students seeking thorough preparation in the field of electronic device physics. It is a combination of the basic electrical engineering and engineering physics curriculums and requires 162 credit hours, distributed over five years. The student will earn two degrees: B.S. in electrical engineering and B.S. in engineering physics.

Two alternative course sequences are listed below. Students who follow the course sequence in the column on the left will complete 134 credit hours, including all of the required electrical engineering courses, by the end of the fourth year and the rest of the 162 credit hours at the end of the fifth year. Since the electrical engineering degree requires 135 credit hours, students normally will complete the requirements for that degree at the end of the ninth semester. It is possible for a student to earn the electrical engineering degree at the end of the eighth semester by accumulating the extra credit hour through advanced placement and/or overload credits.

In the alternate course sequence, the column on the right, the student completes 132 credit hours by the end of the fourth year, including all the required physics courses, and the rest of the 162 credits at the end of the fifth year. Since 131 credit hours are required for the engineering physics degree, the student will complete the requirements for that degree at the end of the fourth year, and the requirements for the electrical engineering degree at the end of the fifth year.

Students interested in a dual-degree program combining physics (rather than engineering physics) and electrical engineering should consult the physics section of this catalog. That program allows the student to earn the B.S. in physics and the B.S. in electrical engineering.

Students interested in either dual-degree program should contact Prof. S. H. Radin, department of physics.

The recommended sequences of courses for the two different EEEP sequences are:

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<tr>
<th>Freshman year (see Section III)</th>
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<tr>
<td><strong>EE-EP</strong></td>
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<tr>
<td><strong>Sophomore year, first semester</strong></td>
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<tr>
<td>Phy 21 (4)</td>
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<td>Phy 22 (1)</td>
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<tr>
<td>ECE 33 (4)</td>
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<tr>
<td>Math 23 (4)</td>
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<tr>
<td><strong>Sophomore year, second semester</strong></td>
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<tr>
<td>Phy 31 (3)</td>
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<tr>
<td>Phy 108 (4)</td>
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<td>Math 205 (3)</td>
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<td>Math 208 (3)</td>
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<td>Phy 212 (3)</td>
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<td>HSS (3)</td>
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<td>ECE 101 (4)</td>
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<th><strong>Junior year, first semester</strong></th>
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<tr>
<td>ECE 121 (2)</td>
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<td>ECE 123 (3)</td>
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<td>Math 231 (3)</td>
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<td>Math 322 (3)</td>
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<td>Phy 212 (3)</td>
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<td>HSS (3)</td>
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<td><em>EP approved electives</em></td>
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<th><strong>Junior year, second semester</strong></th>
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<td>ECE 126 (3)</td>
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<td>ECE 138 (2)</td>
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<td>Phy 213 (3)</td>
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<tr>
<td>Phy 362 (3)</td>
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<tr>
<td>ECE 125 (3)</td>
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<td>HSS (3)</td>
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<td><em>EP approved electives</em></td>
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<th><strong>Senior year, first semester</strong></th>
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<td>ECE 111 (1)</td>
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<td>ECE 251 (2)</td>
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<tr>
<td>ECE approved elective (3)</td>
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<td>Phy 215 (4)</td>
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<td>Phy 363 (3)</td>
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<td>HSS (3)</td>
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<th><strong>Senior year, second semester</strong></th>
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<tr>
<td>ECE 136 (3)</td>
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<td>ECE approved electives (9)</td>
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<td>HSS (3)</td>
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<td>Elective (3)</td>
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<td>Elective* (3)</td>
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<td>Elective (6)</td>
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<th><strong>Fifth year, first semester</strong></th>
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<tr>
<td>Phy 260 (2)</td>
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<tr>
<td>Phy 340 (3)</td>
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<tr>
<td>or ME104 (3)</td>
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<td>EP Approved Elective* (3)</td>
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<td>Elective (6)</td>
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<th><strong>Fifth year, second semester</strong></th>
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<tr>
<td>Phy 171 (1)</td>
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<td>Phy 261 (2)</td>
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</table>
EP appr. elec.* (5) \[ \text{Electives} (3) \]
Electives (6) \[ \text{Total Credits} 162 \]
Credits in 4 years 134 \[ \text{Req. for EE degree} 35 \]
*EP approved electives* \[ \text{Total Credits} 162 \]

** Must include ECE 251 or 252 or Phy 273 (must be a design semester opposite that in which Engr 1 is rostered. Pass-fail grading.

## Engineering

Engr 1 and Engr 2 are required of all engineering and applied science majors and are taken in the recommended freshman year.

### Engr 1. Engineering Computations (3) fall-spring
An introductory survey of computing for students in engineering and the sciences. The course covers basic programming concepts, structures and algorithms. Applications to solving scientific problems. Case studies from utilization of computers in various engineering disciplines. Prerequisite: none. (ES 1)

### Engr 2. Introduction to Engineering (1) fall-spring
Introduction to the engineering profession through a series of lectures and demonstrations. Emphasis is on describing the diversity of engineering career opportunities and the associated curricular choices. To be rostered by freshman students in the P.C. Rossin College of Engineering and Applied Science in the semester opposite that in which ENGR 1 is rostered. Pass-fail grading.

### Engr 3. Freshman Design Experience (2) fall-spring
This course is designed to introduce students to the process of design through a series of lectures and the experience of working on a project design team. Small groups of students will work closely with a faculty member supervising a design project. Lectures will supply information about different aspects of design. Laboratory experiences will assist the student in developing the project design. All students will be required to participate in written and oral presentations.

### Engr 101. (BUS 201) Integrated Product Development (IPD) Projects (3) spring
Business, engineering, and design students work in cross-disciplinary teams of 4-6 students on marketing, financial and economic planning, economic and technical feasibility of new product concepts. Teams work on industry projects with faculty advisors. Oral presentations and written reports. Open to junior or senior students in business, economics or arts.

### Engr 160. Engineering Internship (1-3)
This course offers students who have attained at least Jr2 standing an opportunity to complement coursework with a work experience. Detailed rules for this course can be obtained from the Associate Dean of Engineering. Report required. P/F grading.

### Engr 200. Engineering Co-op (3)
Undergraduate students who are officially enrolled in the college's co-op program are eligible for 1-6 credits of free electives. These credits will be taken P/F. Typically, students will take 3 credits of Engr 200 for the fall semester of junior year work experience and another 3 credits the following summer.

### Engr 250. Computer Modeling of Scientific and Engineering Systems (3) fall
Introduction to the mathematical modeling of scientific engineering systems, with emphasis on higher-order nonlinear models for which analytical methods are precluded. Solution of the model equations by computer-based numerical algorithms. Introduction to numerical methods for linear and nonlinear algebraic systems, ordinary and partial differential equations, error analysis and control, stability and convergence in numerical calculations. Prerequisites: Engr 1; Math 205, previously or concurrently. (ES 1) (ED 1)

### Engr 400. Engineering Co-op for Graduate Students (3)
Supervised cooperative work assignment to obtain practical experience in field of study. Requires consent of department chairperson. When on a cooperative assignment, the student must register for this course to maintain continuous student status. Limit to one semester per two years of matriculation. This course will not count toward completion of the masters degree. These credits will be taken P/F.

### Engr 475. Research (1)
Projects conducted under the supervision of a faculty advisor. Includes analytical, computational or experimental work, literature searches, assigned readings. Regular meetings with the advisor to consider progress made and future direction are required. The course is open only to graduate students and may be repeated for credit. Prerequisite: Graduate standing and departmental approval.

## Engineering Mathematics

### Professors
Philip A. Blythe, Ph.D. (Manchester, England); Terry J. Delph, Ph.D. (Stanford); Fazil Erdogan, Ph.D. (Lehigh); D. Gary Harlow, Ph.D. (Cornell) chair; Stanley H. Johnson, Ph.D. (Berkeley); Arturs Kalnins, Ph.D. (Michigan); Jacob Y. Kazakia, Ph.D. (Lehigh); Antonios Liakopoulos, Ph.D., (Florida); Alistair K. Macpherson, Ph.D. (Sydney); Herman F. Nied (Lehigh); Kenneth N. Sawyers, Ph.D. (Brown); Eric Varley, Ph.D. (Brown); J. David A. Walker, Ph.D. (Western Ontario).

### Assistant professors
Alparslan Öztökin (Illinois).

The Division of Engineering Mathematics was established within the Department of Mechanical Engineering and Mechanics to foster interdisciplinary research in the application of mathematics to the engineering and physical sciences. Interaction with industry is actively encouraged, and appropriate programs are designed for part-time students. Program content for all students is developed through close consultation with division faculty.

For a description of the graduate programs in applied mathematics see the discussion under Interdisciplinary Graduate Programs. Engineering mathematics courses are listed under mechanical engineering and mechanics.

## English

### Professors
Barbara H. Traister, Ph.D. (Yale), chair; Peter G. Beidler, Ph.D. (Lehigh), Lucy G. Moses Distinguished Professor; Addison C. Bross, Ph.D. (Louisiana State); Jack A. De Bellis, Ph.D. (U.C.L.A.); Jan S. Fergus, Ph.D. (C.U.N.Y.); Elizabeth N. Fifer,
Undergraduate Major in English

The major in English is designed to give students experience in reading, analyzing, and formulating thoughts about people and ideas that matter; an understanding of how literary artists find the appropriate words to express their thoughts and feelings; and a basic knowledge of the historical development of British, American, and world literature. Students who major in English go on to careers in teaching, writing, law, business, science, medicine, engineering—and many others. The analytical and communication skills acquired in the study of literature and writing will be of use in almost any profession or human activity. Depending on their interests, abilities, and career plans, students who major in English are encouraged to consider double majors or one or two minors in other fields. The major in English is flexible enough to allow cross-disciplinary study with ease.

The student majoring in English chooses from an extensive list of courses. To ensure breadth of coverage each English major is required to take the following courses:

- **English 100** Working with Texts (4)
- **English 290** Senior Seminar (4)

Four 300-level courses distributed over the following periods (British or American survey may substitute for one 300 level course):

1. British to 1660 (Engl. 125, 327, 328, 360, 362, 364)
2. British 1660-1900 (Engl. 125, 126, 331, 366, 367, 369, 371, 372)
3. American to 1900 (Engl. 123, 376, 377, 378)
4. 20th C American, British, World, Film, Popular Culture (Engl 124, 126, 379, 380, 383, 384, 385, 387)

In addition, each English major elects at least three more courses in literature or film with the following qualifications:

- at least one at the 300-level if a survey fulfills one of the period requirements
- 1 elective may be 2-4 credits

These nine courses are the minimum for the major. Many of our students will elect to take more, depending on their career plans, their other majors and minors, their plans to study abroad, and so on. Each major has a departmental advisor to assist in selecting courses and to offer counsel about career plans.

The department strongly recommends that any student contemplating the possibility of advanced study of literature at the graduate level should work toward departmental honors.

**Departmental Honors in English**

In order to receive departmental honors the English major must attain a 3.3 grade-point average in courses presented for the major and must complete at least 41 credit hours of course work in English (beyond English 1 and 2). For the additional credits beyond the 34 required of all English majors, honors students must take one of the following two courses:

- Engl 387, Film History and Criticism, or
- Engl 309, Interpretation: Critical Theory & Practice

and either

- Engl 307 (or 308), Thesis, or
- Engl 4—, a graduate seminar, by petition.

Because most graduate schools require language examinations, the department also strongly recommends that students going for honors achieve at least second-year college competency in at least one foreign language. Students who complete the courses required for departmental honors but who do not achieve the necessary grade-point average will receive the bachelor of arts degree with a major in English.

**Presidential Scholars**

Students who anticipate becoming Presidential Scholars should speak to the Director of Graduate Studies in their junior year.

**Minors in English**

The Department of English offers three minors, each requiring 16 hours of course work beyond English 1 and 2. Students' major advisors monitor the minor programs, but students should consult the minor advisor in the Department of English when setting up a minor program.

To minor in British literature, students take Engl 125, Engl 126, and two more courses in British literature, at least one of them at the 300-level.

To minor in American literature, students take Engl 123, Engl 124, and two more courses in American literature, at least one of them at the 300-level.

To minor in writing, students take Engl 171, Engl 173, or Engl 174 and Engl 201, Engl 347 or Engl 373. They must also take two more courses chosen from Engl 171, 173, 174, 201, 281, 347, 373 Journ 11, 111, 123, 212.

**Graduate Work in English**

We prepare our students to meet contemporary demands for faculty who value excellence in teaching and scholarship.

**The Master of Arts Program**

Applicants for the M.A. program should have an undergraduate English major. Students who did not major in English may be admitted but will need to supplement their undergraduate training in English.

Candidates for the master's degree must complete at least 30 credit hours. Students take at least seven of the required courses (including "thesis papers") at the 400 level but may select the balance of their curricula from 300-level course offerings. Course work for the M.A. must include two courses in literature before 1660; two courses in the period between 1660 and 1900; two courses from 1900 to the present; and one course in literary theory. At least two of these courses must be in American literature and at least four in British literature. Up to six hours of collateral work in other departments may be included in a master's program.

Instead of writing the traditional "thesis," M.A. candidates write two or three shorter "thesis papers," certified by faculty advisors as ready for submission to a session organizer as a conference presentation or to a professional journal for possible publication.

**The Doctor of Philosophy Program**

The department admits to its doctoral program only students of proven competence and scholarly promise. An average of 3.5 in M.A. coursework and strong endorsements from graduate instructors are minimum requirements for acceptance.
Doctoral candidates with a Lehigh master's degree are required to take eight courses and register for 42 credit hours beyond the M.A. Those entering the doctoral program with a master's from another institution are required to take nine courses and register for 48 credit hours.

Candidates must also demonstrate a reading knowledge of one or two foreign languages after having agreed on choices with the director of graduate studies.

No later than six months after completing their course work, candidates will take written and oral examinations in one major field and two minor fields.

Candidates write their dissertations after having their dissertation proposals approved by the department and being admitted to candidacy by the appropriate college.

Freshman Composition Requirement
With the two exceptions noted below, all undergraduate students take six credit hours of freshman English courses: English 1 and English 2 (or one of the alternatives to Eng 2 such as 4, 6, 8, or 10). The exceptions are:

1. Students who receive Advanced Placement or received 700 or higher on SAT II English exam with essay, please see page 5.
2. Students with English as a Second Language. Categories include students on non-immigrant visas, students on immigrant visas, registered aliens, and citizens either by birth or by naturalization.

Students in all these categories for whom English is not the first language may petition for special instruction through the program in English as a Second Language.

At matriculation, all foreign students take an English language competency test to determine the kind of instruction best suited to their needs. Matriculating freshmen judged to be qualified will roster Eng 1, followed by Eng 2, 4, 6, 8, or 10. Others will be enrolled in Eng 3, followed by Eng 5 (or 2, 4, 6, 8, or 10).

Students enrolled in the English as a Second Language program are expected to reach a level of competence comparable to those in the usual freshman program. The form of instruction, however, will differ in the ESL program by taking into account the special problems of non-native speakers. Matriculating students in all the above categories who are entering at a level above the freshman year, but who need composition credit, should consult the department for advice.

Freshman Courses
Eng 1. Composition and Literature (3) fall
Emphasis on the writing process, especially on revising for cogency and clarity. Topics drawn mainly from everyday life and culture.

Eng 2. Composition and Literature II (3) spring
Continuation of Eng 1. Emphasis on making informed, thoughtful, and well-supported claims about issues of broad public concern. Topics vary by section. Texts include both expository and literary selections, as well as films and other media. Prerequisite: Eng 1.

Eng 3. Composition and Literature I for ESL Writers (3) fall
 idiomatic English both oral and written, with a strong emphasis on producing well-organized, coherent essays. Enrollment limited to non-native speakers; placement is determined after testing by the Department of English.

Eng 4. Composition and Literature II: Special Topic A (3) spring
Continuation of Eng 1. Similar to Eng 2, except that the topic will be announced in advance. Topics vary from year to year. Students must register through the English department. Prerequisites: Eng 1 and consent of department.

Eng 5. Composition and Literature II for ESL Writers (3) spring
Continuation of English 3.

Eng 6. Composition and Literature: Special Topic B (3) spring
Continuation of Eng 1 I. Similar to Eng 2, except that the topic will be announced in advance. Topics vary from year to year. Students must register through the English department. Prerequisites: Eng 1 and consent of department.

Eng 7. Composition and Literature: Special Topic C (3) spring
Continuation of Eng 1 I. Similar to Eng 2, except that the topic will be announced in advance. Topics vary from year to year. Students must register through the English department. Prerequisites: Eng 1 and consent of department.

Eng 8. Composition and Literature: Special Topic D (3) spring
Continuation of Eng 1 I. Similar to Eng 2, except that the topic will be announced in advance. Topics vary from year to year. Students must register through the English department. Prerequisites: Eng 1 and consent of department.

Eng 9. Literature Seminar for Freshmen (3) fall
Alternative to Composition and Literature for freshmen who have earned exemption from Eng 1 and qualify for a seminar in literature. Recommended especially for qualified students who are considering a major in the humanities. Topics vary by section. Prerequisite: score of 4 or higher on Advanced Placement Test in English or 700 or higher on the SAT II Subject Test in Writing.

Undergraduate Courses
Eng 52, 54, 56, and 58 are open to all undergraduates, including first-year students also taking freshman English. Courses numbered at the 100-level are open to students who have completed or who are exempt from the required six hours of freshman English. First-year students who have completed English 1 with a grade of A or A- may roster one of the 100-level courses as a second English course to be taken concurrently with the second-semester English composition requirement.

Prerequisites: Each course is a self-contained unit. None has any other prerequisite than two semesters of freshman English. Thus, students may roster English 126 whether or not they have had, or ever plan to take, English 125. For all courses above 200, it is understood that students will have completed six hours of freshman English, even though that is not specified in the course description.

Eng 38. (AAS 38) Introduction to African Literature (3)
Sub-Saharan African literary themes and styles; historical and social contexts, African folktales, oral poetry, colonial protest literature, postcolonial writing, and films on contemporary Africa. Staff. (HU)

Eng 52. (Clss 52) Classical Epic (3)
Study of major epic poems from Greece and Rome. Works include Homer's Iliad and Odyssey, Apollonius' Argonautica, Vergil's Aeneid, and Ovid's Metamorphoses. Pavlock. (HU)

Eng 54. (Clss 54, Thtr 54) Greek Tragedy (3)
Aspects of Greek theater and plays of Aeschylus, Sophocles, and Euripides in their social and intellectual contexts. Pavlock. (HU)

Eng 56. (Clss 56) The Ancient Novel (3)
Examination of the origins of the novel in Greece and Rome. Includes the picaresque novel. Pavlock. (HU)

Eng 58. (Clss 58, Thtr 58) Greek and Roman Comedy (3)
Study of comedy as a social form through plays of Aristophanes, Menander, Plautus, and Terence. Pavlock. (HU)
Engl 60. (Thtr 60) Dramatic Action (4)
How plays are put together; how they work and what they accomplish. Examination of how plot, character, aural and visual elements of production combine to form a unified work across genre, styles and periods. Recommended as a foundation for further studies in design, literature of performance. (HU)

Engl 91. Special Topics (1-4)
A topic, genre, or approach in literature or writing not covered in other courses. (HU)

Engl 100. Working with Texts (4)
A course to help students to become, through intense practice, independent readers of literary and other kinds of texts; to discern and describe the devices and process by which texts establish meaning; to gain an awareness of the various methods and strategies for reading and interpreting texts; to construct and argue original interpretations; to exam and judge the interpretations of other readers; to write the interpretive essay that supports a distinct position on some literary topic of importance; and to learn to find and assimilate into their own writing appropriate information from university library resources. To be rostered as early as possible in the English major's program. Departmental approval required. (HU)

Engl 120. Literature from Developing Nations (4)
Contemporary literature from Africa, Central and South America, and Asia. Prerequisite: six hours of freshman English. Fifer. (HU)

Engl 122. Speculative Fiction (4)
The study of "hard" science fiction and mythic fantasy from philosophical and scientific as well as aesthetic and literary perspectives. Prerequisite: six hours of freshman English. (HU)

Engl 123. American Literature I (4)
American literary works through the mid-19th century. Prerequisite: six hours of freshman English. (HU)

Engl 124. American Literature II (4)
American literature from the middle of the 19th century to the present. Prerequisite: six hours of freshman English. (HU)

Engl 125. British Literature I (4)
British literature and literary history from Beowulf through the Pre-Romantics. Prerequisite: six hours of freshman English. (HU)

Engl 126. British Literature II (4)
British literature and literary history from the Romantic period into the 20th century. Prerequisite: six hours of freshman English. (HU)

Engl 127. (Thtr 127) The Development of Theatre and Drama from Ritual to Renaissance (4)
Historical survey of western theatre and dramatic literature from their origins to the Renaissance. (HU)

Engl 128. (Thtr 128) The Development of Theatre and Drama from Renaissance to Present (4)
Historical survey of western theatre and dramatic literature from the Renaissance to the modern era. (HU)

Engl 155. The Novel (4)
Selected novels, with attention to such matters as narrative, characterization, and cultural context. Prerequisite: six hours of freshman English. (HU)

Engl 157. Poetry (4)
Selected traditional and modern poetry, with attention to voice, form, and cultural context. Prerequisite: six hours of freshman English. (HU)

Engl 163. Topics in Film Studies (4)
History and aesthetics of narrative film. May be repeated for credit as subject varies. Prerequisite: six hours of freshman English. Doty. (HU)

Engl 171. Writing for Audiences (4)
Practice in writing in a variety of discourse modes for different audiences. Consideration of the role of style, clarity, and careful observation in writing. Prerequisite: six hours of freshman English. (ND)

Engl 173. Personal Writing (4)
Practice in writing from immediate experience, with emphasis on accurate, persuasive descriptive writing. Prerequisite: six hours of freshman English. (ND)

Engl 174. Creative Writing Workshop (4)
Practice in and classroom criticism of creative writing done by students taking the course. Title may vary: Short Story; Drama; Poetry; etc. May be repeated for credit. Prerequisite: six hours of freshman English. (ND)

Engl 175. Individual Authors (4)
Intensive study of the works of one or more literary artists, such as Austen, Hemingway, and Kerouac. May be repeated for credit as artists and works vary. Prerequisite: six hours of freshman English. (HU)

Engl 177. Individual Works (4)
Intensive study of one or more literary works, such as Moby Dick and Stories of John Cheever. May be repeated for credit as works vary. Prerequisite: six hours of freshman English. (HU)

Engl 183. Independent Study (1-4)
Individually supervised study of a topic in literature, film, or writing not covered in regularly listed courses. Prerequisite: consent of the department chairperson. (HU)

Engl 187. Themes in Literature (4)
Study of a theme as it appears in several works of literature, such as Utopia and the quest. May be repeated for credit as titles and themes vary. Prerequisite: six hours of freshman English. (HU)

Engl 189. Popular Literature (4)
The form of literature that has been designated in one way or another as "popular," such as folklore and detective fiction. May be repeated for credit as titles and themes vary. Prerequisite: six hours of freshman English. (HU)

Engl 191. Special Topics (1-4)
A topic, genre, or approach in literature or writing not covered in other courses. Prerequisite: six hours of freshman English. (HU)

Engl 201. Special Topics in Writing (1-4)
Approaches not covered in other writing courses. Individual projects. May be repeated for credit. Prerequisite: Engl 171, 173, or 174, or permission of writing minor advisor. (ND)

Engl 281. Writing Internship (1-4)
Projects on- or off-campus in professional, governmental, or service organizations. Experience must include extensive writing that can be submitted for review. Enrollment limited to juniors or seniors with a major or minor in English. May be repeated for credit. Prerequisite: approval of department internship advisor or department chair. (ND)

Engl 290. Senior Seminar (4)
In-depth study of a problem, issue, question, or controversy. Enrollment limited to 15 students. Required writing intensive course for English majors. May be repeated for credit, space
permitting, as title varies. Department approval required. Prerequisite: senior English major standing. Staff (HU)

Engl 291. Special Topics (1-4)
A topic, genre, or approach in literature or writing not covered in other courses. (HU)

Graduate Students taking 500-level courses receive 3 credits; undergraduates receive 4 credits.

Engl 301. Topics in Literature (4)
A theme, topic, or genre in literature, such as autobiography as literature and the gothic novel. May be repeated for credit as titles vary. (HU)

Engl 307. Undergraduate Thesis (3)
Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of the department chair. (HU)

Engl 308. Undergraduate Thesis (3)
Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of department chairperson. (HU)

Engl 309. Interpretation: Critical Theory and Practice (4)
Introduction to recent literary and cultural theory, such as New Criticism, Structuralism, Marxism, Psychoanalytic approaches, Reader-response Criticism, Deconstruction, Feminist Theory, New Historicism, and Cultural Criticism. Bross, Gordon, Mundhenk. (HU)

Engl 310. Introduction to Theory and Methods of English as a Second Language Instruction (4)
An introduction to teaching English as a second language including the theory and principles of second language acquisition, ESL methods, materials, and current trends with a special emphasis on teaching ESL writing. Course restricted to upperclass and graduate students. (HU) Rance-Roney

Engl 311. (WS 311) Literature of Women (4)
Women's works about women. Besides re-reading familiar feminists' fiction, drama, and poems, an introduction to contemporary and often experimental works by less famous writers. (HU)

Engl 316. Native American Literature (4)
Fiction by modern American Indian writers like N. Scott Momaday, Leslie Marmon Silko, James Welch, Michael Dorris, and Louise Erdrich. Some attention given to the history of the relationships and conflicts between Native Americans and the federal government, white agriculture and business interests, and educational and religious interests. Beidler (HU)

Engl 327. Chaucer (4)
The Canterbury Tales, with some attention to other Chaucerian works and other works that may have provided source-materials for Chaucer's tales. Chaucer's language and the literary, intellectual, social, and historical backgrounds to his work. Beidler (HU)

Engl 328. (Thtr 328) Shakespeare (4)
An introduction to Shakespearean drama including comedies, histories, tragedies, and romances. Emphasis on textual study, cultural contexts, and performance strategies. Hawkes, Traister (HU)

Engl 331. Milton (4)
The poetry and prose of John Milton in the context of the English Revolution. Particular attention to the intersection of theology and philosophy, and of the personal with the political. Hawkes. (HU)

Engl 347. The Essay (4)
Practice of the essay, including such forms as the personal, academic, or argumentative essay. Emphasis on developing a strong personal voice and learning to use other voices. Intensive revision. Prerequisite: Engl 171, 173, or 174, or permission of writing minor advisor. (ND)

Engl 360. Middle English Literature (4)
Major literary works of the Middle English period by authors other than Chaucer. Emphasis on Piers Plowman, the Gawain/Pearl Poet, and the metrical romances. Ingham. (HU)

Engl 362. The Sixteenth Century (4)
Humanist, Petrarchan and dramatic traditions in the literature of Renaissance England. Readings from such authors as Erasmus, More, Wyatt, Sidney, Spenser, and Marlowe. Traister (HU)

Engl 364. The Seventeenth Century (4)
Literature of the seventeenth century, by such writers as Donne, Herbert, Jonson, Browne, Burton, Milton, Hobbes, Bunyan, and Locke, chronicling the unprecedented variety of aesthetic, political, and social innovations in this "century of revolution." Hawkes, Traister. (HU)

Engl 366. The Restoration and Early Eighteenth-Century (4)
Restoration and early eighteenth-century literature, with attention to the cultural forces that shaped the writers and their works. Readings will include Dryden, Behn, Rochester, Wycherley, Congreve, Swift, Finch, Pope, Addison and Steele. Gordon. (HU)

Engl 367. The Eighteenth Century (4)
Poetry, drama and prose of the eighteenth century, with attention to cultural forces that shaped the writers, their works, and their position in the canon. Readings of Montagu, Burney, Wollstonecraft, Austen, Fielding, Richardson, Johnson, Sheridan, Sterne, in addition to a few earlier writers. Fergus, Gordon (HU)

Engl 369. British Romantic Literature (4)
Poetry and prose of Wordsworth, Coleridge, Byron, Shelley, and Keats within the contemporary, political, religious, and social context. Bross (HU)

Poetry and prose of Tennyson, Browning, Arnold, Swinburne, Carlyle, Mill, Newman, and Ruskin within the contemporary political, religious, and social contexts. Bross. (HU)

Engl 372. British Victorian Literature: Fiction (4)
Major fiction of the Victorian era by such writers as Dickens, Eliot, Thackeray, and Hardy within historical, social, and aesthetic contexts. Mundhenk. (HU)

Engl 373. Advanced Creative Writing Workshop (4)
Advanced practice in and classroom criticism of creative writing done by students taking the course. Emphasis may vary among: fiction, poetry, creative essay, drama, etc. May be repeated for credit. Prerequisite: English 174, or permission of writing minor advisor. (ND)

Engl 375. Major Authors (1-4)
The works of one or more major literary figures studied in depth. May be repeated for credit as titles and authors vary. (HU)

Engl 376. Early American Literature (4)
The literature of New England, the Middle Colonies, the South, and the Southwest from Columbus to the close of the eighteenth century, emphasizing our cultural and artistic diversity. Gallagher. (HU)
engl 377. american romanticism (4)
emerson, thoreau, whitman, hawthorne, melville, dickinson, poe, and their contemporaries. philosophical, historical, and social background, as well as the aesthetic study of romantic literary works. debellis. (hu)

engl 378. american realism (4)
theory and practice of realistic and naturalistic fiction from the civil war to the early twentieth-century: twain, howells, james, norris, crane, dreiser, wharton, and regionalists. frakes. (hu)

engl 379. twentieth-century american literature (4)
american literature before world war ii. lectures and class discussion of major fiction and poetry. debellis, mundhenk. (hu)

engl 380. contemporary american literature (4)
american literature since world war ii. lectures and class discussions of new writers and of recent works of established writers. debellis, frakes. (hu)

engl 382. themes in american literature (4)
intensive study of one topic in american literature. readings from the colonial period to the present. may be repeated for credit as title varies. (hu)

engl 383. modernism and post-modernism in fiction (4)
the "anti-realistic" novel; time/space, point of view, narrative voice, structure as meaning. kafka, woolf, beckett, nabokov, robbe-grillet, faulkner, borges, hawkes, stein. frakes. (hu)

engl 384. twentieth-century world literature (4)
world literature (europe, asia, south america, africa) from 1900 to present. fifer. (hu)

engl 385. modern british and continental literature (4)
world english literature and continental literature before world war ii. lectures and class discussion of major fiction. frakes. (hu)

engl 386. contemporary british and continental literature (4)
world english literature and continental literature after world war ii. fifer, frakes. (hu)

engl 387. film history, theory, and criticism (4)
study of film with the focus on particular genres, directors, theories, periods, or topics. weekly film screenings. may be repeated for credit as title varies. doty. (hu)

engl 388. independent study (1-4)
individually supervised study of a topic in literature, film, or writing not covered in regularly listed courses. prerequisite: consent of department chairperson. (hu)

engl 391. special topics (1-4)
a topic, genre, or approach in literature or writing not covered in other courses. (hu)

graduate courses in english
the following courses are seminars, ordinarily limited to no more than twelve graduate students, but undergraduate english majors who are planning to go on to graduate school in english and who have shown proficiency in the study of literature may petition to take one of these seminars in their senior year.

engl 400. supervised teaching (1)
practical experience in teaching through assisting a faculty teacher in conduct of a regularly scheduled undergraduate course. open only to graduate students with at least one semester of graduate course work at lehigh university and a gpa of at least 3.5. usually rostered in conjunction with 485. prerequisite: consent of the department chair.

engl 421. history of the english language (3)
The phonology, grammar, and lexicon of English from the beginnings to the present. ingham

engl 423. anglo-saxon language and literature (3)
An introductory study of the Anglo-Saxon culture through its language and literature. special attention given to translation and interpretation of the epic poem Beowulf. ingham

engl 433. middle english literature (3)
course may be repeated for credit as title varies. possible offerings:
Arthurian Romance and History: an inquiry into medieval Arthurian literature from Celtic traditions to Malory's Morte D'Arthur. Focus given to the influences these texts craft between fantasy and politics, and the problems of a literary history that understands "romance" and "history" as opposing terms. ingham
Chaucer: a study of selected works by Geoffrey Chaucer, with attention to his language, his sources, his cultural backgrounds that inform his poetry, and trends in modern criticism of his works. beidler

insular literary cultures: A study of selected "British" works from a variety of cultures (Scots, Irish, Welsh, Middle-English, Anglo-Norman, Monastic, Lollard, etc.) written (or popular) from 1300-1500. careful attention given to reading texts in a larger cultural (and "multi-cultural") context. ingham.

origins of british drama: A study of several medieval plays, like Everyman, the Second Shepherds' Play, and selected plays in one of the mystery play cycles. brief consideration of the dramatic techniques of Chaucer's poetic fiction as a precursor to the drama that was to flourish centuries later. beidler

engl 439. sixteenth-century british literature (3)
course may be repeated for credit as title varies. possible offerings:
Renaissance love poetry: study of the sixteenth century sonnet sequence, epyllion, and Ovidian lyric. works by Wyatt, Surrey, Marlowe, Sidney, Fulke Greville, Spenser, and Shakespeare. traister
City and Court under Elizabeth and James: study of how the City (London) and the Court under each monarch are represented in contemporary texts—in drama, poetry, letters, sermons, and prose tracts. traister

engl 441. seventeenth-century british literature (3)
course may be repeated for credit as title varies. possible offerings:
literature of the English Revolution: Examination of the causes, circumstances, and consequences of the English Revolution as expressed from 1640-1670. readings in: Hobbes, Harrington, Lilburne, Milton, Marvell, and Bunyan. hawkes
Theology and Interpretation in the Renaissance: Drawing on the hermeneutics of Luther and Calvin, the course will focus on how English writers of the sixteenth and seventeenth centuries elaborated a distinctively Protestant mode of signification. Writers studied will include Jonson, Donne, Herbert, Traherne, Browne, and Bunyan. hawkes

engl 442. restoration and early eighteenth-century british literature (3)
course may be repeated for credit as title varies. possible offerings: Restoration and Early Eighteenth-Century Drama: Examination of the drama written between 1660 and 1720 and of the culture shaping it and shaped by it. Cavendish, Philips, Dryden, Behn, Wycherley, Etheridge, Congreve, Shadwell, Steele will be among the writers studied. gordon
Tory Feminist? Close investigation of the complex position of early modern women writers (including Cavendish, Philips, Behn, Pix, Centlivre, Finch, Montagu); consideration of the conditions of authorship, for men and women, in late seventeenth-century Britain. Gordon

Frances Burney and Jane Austen: Major novels of Burney and the novels and juvenilia of Austen in their social and literary contexts. Examination of what it means to be a professional writer between 1770-1820. Gordon

Literature in the Marketplace: Study of the eighteenth-century marketplace through examining “canonical” works in relation to the print culture that engendered and then imitated them. Sources for this examination include periodical literature, children’s books, “minor” fiction, and booksellers’ records. Gordons

Engl 445. Nineteenth-Century British Literature (3)
Course may be repeated as title varies. Possible offerings:
The Victorian Novel and Poststructural Theory: Intensive study of three or four Victorian novels, by writers such as Dickens, Eliot, Bronte, and Thackeray, through the lens of Feminist, Marxist, Psychoanalytical, Deconstructive, and Cultural theory. Mundhenk

The Problem of Knowledge in the Victorian Age: Given the new kinds of knowledge emerging in their time, such writers as Dickens, Carlyle, Mill, Marx, Eliot, Tennyson, Browning, Arnold, Ruskin, and Newman had to ponder the question: What notions—religious doctrines, for example, or scientific observations—should be considered “knowledge”? Bross

Engl 449. Twentieth-Century British Literature (3)
Course may be repeated as title varies. Possible offerings:
James Joyce: Close examination of the works of James Joyce, with special attention to style, narrative voices, and thematic complexity. Frakes

Modern British Fiction: Concentration on one or more major figures: Joyce, Conrad, Shaw, Forster, Woolf, Lawrence, Beckett. Revitalized “New Critical” approaches. Frakes

Engl 471. Early American Literature (3)
Course may be repeated as title varies. Possible offerings:
Benjamin Franklin and the American Character: In-depth study of Franklin’s work, life, and career, as well as study of his influence and reputation through works written about him—some loving, some vicious—from John Adams to John Updike. Gallagher

Early American Literature: A broad survey of literature from Columbus to the end of the eighteenth century, focusing on important writers, geographical and cultural diversity, and diverse literary forms (history, sermon, poetry, autobiography, novel, travel narrative, political essay). Gallagher

Engl 473. Nineteenth-Century American Literature (3)
Course may be repeated as title varies. Possible offerings:
Emerson, Dickinson, Frost: Emerson’s philosophy, literary theory, and poetry as the context in which we consider the poetry of Dickinson and Frost.

Literary Watersheds: Close reading, critical reputation, and contemporary approaches to four works that transformed and invented our national literature: Moby Dick, Uncle Tom’s Cabin, Walden, and Leaves of Grass.

Henry James: Close Examination of the works of The Master: short stories, novellas, and major novels. Varied critical approaches. Frakes

Literary Realism and Naturalism: Selected fiction by one or more of the following pioneers in American literary realism and literary naturalism: Henry James, Mark Twain, Stephen Crane, William Dean Howells, Frank Norris, and Theodore Dreiser.

Frakes

Engl 477. Modern American Literature (3)
Course may be repeated for credit as topic varies. Possible offerings:
Ernest Hemingway: Heightened “New Critical” approaches to the short stories and major novels of Ernest Hemingway. Frakes

Modern American Fiction: Heightened “New Critical” approaches to one or more major fiction writers from 1900 to 1950: Hemingway, Faulkner, Fitzgerald, Dos Passos, West, Porter. Frakes

Modern Southern Writers: Major Southern writers since 1920 from all regions including Styron, O’Connor, Williams, Faulkner, Welty, Percy, Porter, Ransom, Tate, and Warren. All genres, and some sub-genres like “Southern Gothic,” will be studied, along with social and philosophical influences. DeBells

Modern American Poetry: The significant poets from 1900 to 1960. The major emphasis falls upon Eliot, Pound, Stevens, and Williams, but other poets could include cummings, Frost, Stein, Hughes, Lowell, Plath, Moore, Dickey, Roethke, and Warren. DeBells

Contemporary American Poetry: Poets from the 1960’s to the present. Such poets as Creeley, Ginsberg, Levine, Rich, Plath, Lorde, Lowell, Kinnell, Baraka. Fifer

Contemporary American Drama: Drama from the 1950’s to the 1990’s. Such playwrights as Mamet, Shepard, Forés, Wilson, Norman, Howe, Wasserstein, Durang and others. Fifer

Contemporary Native American Fiction: Short stories and novels by American Indian writers since the mid-1960’s, including Momaday, Silko, Welch, Dorris, and Erdrich. There will be special focus on the novels of Louise Erdrich. Beidler

Engl 480. Composition and Rhetoric (3)
Basic theories and works in composition and rhetoric, with some attention to classical rhetoric, but with primary emphasis on modern rhetoric and discourse theory, including Burke, Kinneavy, Moffett, and Britton, as well as theories of the writing process. Consideration of linguistics as it applies to teaching writing, and the history of teaching writing in America. Kroll, Lotto

Engl 481. Theory and Criticism (3)
Course may be repeated for credit as title varies. Possible offerings:
Theories of Authorship in Literature and Film:
Material from Western Romanticism through theorists such as Derrida, Barthes, and Foucault. Focus on film auteurism and structuralist, post-structuralist, and feminist, marxist, and gay/lesbian challenges to and reconceptualization of notions of authorship. Doty

The Ideology of the Aesthetic: Consideration of the aesthetic impulse and its relationship to rhetoric and literary criticism. Readings from Lentricchia, Eagleton, the Frankfurt School, Jameson, Burke, Bakhtin, and Bourdieu. Lotto


Advanced Critical Theory: Study of several important and influential recent theoretical texts. Emphasis on “pure” rather
than “applied” theory: readings from Macherey, Derrida, Baudrillard, Kristeva, and Jameson. Hawkes

Feminist Theory: Culture, Gender, and Agency: A study of selected works of feminist theory with special emphasis on the interventions gender theorists have made into discourses of culture and agency. Readings from Irigaray, Kristeva, Rubin, deBeauvoir, Hooks, Spillars, Abel, Alarcon, Harraway, Butler, and others. Ingham

Engl 485. Introduction to Writing Theory (2)
Survey of major approaches and theoretical issues in the field of composition and rhetoric. Required of all new teaching assistants in the department. Usually rostered in conjunction with 400 or 486.

Engl 486. Teaching Composition: A Practicum (1)
Introduction to teaching writing at Lehigh. Bi-weekly discussions of practical issues and problems in the teaching of freshman composition. Required of all new teaching assistants in the department. Usually rostered in conjunction with English 485.

Engl 491. Special Topics (1-3)
A topic, genre, or approach in literature or writing not covered in other courses. May be repeated for credit as title varies. Prerequisite: consent of the graduate program coordinator.

Engl 493. Graduate Seminar (3)
Intensive study of the works of one or more authors, or of a type of literature. May be repeated for credit as title varies.

Engl 495. Independent Study (3)
Individually supervised course in an area of literature, film or writing not covered in regularly listed courses. Prerequisite: consent of the graduate program coordinator.

English as a Second Language

Program Director. Judith A. Rance-Roney, Ed.D. (Lehigh)

English as a Second Language (ESL) courses are offered to both undergraduates and graduates who wish to increase English proficiency in the areas of writing, reading, speaking, and presentation skills. All courses are at an advanced level of English study. For undergraduates, these courses are designed to supplement, not replace, English department required courses, such as courses towards the freshman writing requirement. An undergraduate may count a maximum of four credit hours of ESL courses towards an undergraduate degree. For graduate students, the courses are designed around the graduate major field. Graduate students should contact their departments regarding acceptance of credit towards residency requirements. ESL courses may be repeated for credit with a maximum of three repetitions.

Enrollment. ESL courses during the fall and spring semesters are open to regularly enrolled students at Lehigh University. Therefore, visas cannot be issued for English language courses alone, nor can students be admitted to Lehigh University only to study ESL except on a one- or two-course basis under the General College Division (GCD) program and with the permission of the ESL director.

Summer Intensive Program. In June, July and August, a special non-credit intensive ESL program called STEP/UP is offered to advanced ESL students who wish to study university/academic English in a challenging environment. This program is open to the general public unlike the fall and spring courses. Contact the ESL program for more information and a brochure.

Testing. English language proficiency testing is conducted for all new incoming undergraduate and graduate students whose first language is not English during new student orientations in August and January. Specific placement in courses will be determined based on the results of this testing.

The Freshman Composition Requirement. The courses English 3 and English 5 (Composition and Literature for ESL Writers I and II) may be applied towards the composition requirement for undergraduates. See the English department course listings for additional information.

ESL Teacher Training. Each year, ESL in conjunction with the English department offers English 310 (Introduction to Theories and Methods of ESL Instruction). See the English department course listings for a description.

For more information about English as a Second Language at Lehigh, refer to our web site at www.lehigh.edu/~inesl

Courses:

ESLP 1 ESL Advanced Structure, Grammar, and Semantics (1)
Instruction in understanding and using advanced English sentence structures in writing and speaking. Advanced academic vocabulary and grammar development to improve writing sophistication and accuracy. 4 hours per week.

ESLP 2 ESL Academic Writing and Reading (1)
The writing process and composing skills, editing skills, vocabulary development and reading fluency for ESL students. Required for graduate students who score below 73 on the Michigan Test and/or for students needing additional writing proficiency. Undergraduates may enroll after or concurrent with English 3. 6 hours per week.

ESLP 3 ESL Clear Speech and Conversation (1)
Conversational English, colloquial language and idioms, pronunciation and accent reduction and practice in basic listening skills for an academic setting. 4 hours per week.

ESLP 4 ESL Academic Speaking (1)
Correct use of grammatical structures in oral English and practice in accurate pronunciation. ESL students will explore the functions of American English in an academic setting. 4 hours per week.

ESLP 11 ESL Technical Writing and Composition (1)
Formal composition and technical writing including general technical vocabulary, technical sentence structure, and research skills for the advanced ESL student. Prerequisite: successful completion of ESLP 2 (ESL Academic Writing and Reading) or ENGL 5, or with permission of ESL Director. 4 hours per week.

ESLP 12 ESL Advanced Speech and Presentation Skills (1)
Development of advanced speaking skills and presentation techniques through a study of formal spoken rhetoric, accent education, and platform skills. For the undergraduate or graduate student seeking formal speech skills and/or for teaching assistants. (Required for TAs with SPEAK scores 200-229.) Prerequisite: successful completion of ESLP 3 or ESLP 4, or SPEAK score 180+, or permission of TAs director. 4 hours per week.

Environment and Society

This program, based principally in the College of Arts and Sciences, is designed for students interested in how people both create and respond to environmental problems, issues, and
constraints. By emphasizing the interrelation between human social systems and environmental circumstances, the minor complements Lehigh’s programs in environmental science and engineering and should be especially attractive to students in those majors.

Many of the minor’s approved courses focus on the public policies and issues associated with current environmental issues; others focus on the longer-term adaptations of social systems to changing environmental situations. Only a few of the courses in the minor have specific prerequisites, so students can easily select a minor program to suit personal tastes and interests, especially if the minor is declared by the end of the sophomore year.

Each student’s minor program consists of courses totaling 15 credits chosen in consultation with the program director from among the courses listed below. The only stipulation is that at least eight credits must be in “core” courses (i.e., courses in which 75%-100% of the subject matter concerns environment and society issues).

For further information, please contact the program director, Sharon M. Friedman, Department of Journalism and Communication, University Center, Room 8C, (738-4179).

Core Courses (minimum of 8 credits)

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Anth/Clss 121</td>
<td>Environment and Culture</td>
<td>3</td>
</tr>
<tr>
<td>Anth 305</td>
<td>Anthropology of Fishing</td>
<td>3</td>
</tr>
<tr>
<td>CE 172</td>
<td>Fundamentals of Environmental Pollution</td>
<td>3</td>
</tr>
<tr>
<td>Eco 311</td>
<td>Environmental Economics</td>
<td>3</td>
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<tr>
<td>Hist 315</td>
<td>American Environmental History</td>
<td>4</td>
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<tr>
<td>Jour 125</td>
<td>Environment, the Public, and the Mass Media</td>
<td>4</td>
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<tr>
<td>Jour/STS 323</td>
<td>Scientific and Environmental Controversies</td>
<td>4</td>
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<td>PolS 111</td>
<td>The Politics of the Environment</td>
<td>4</td>
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<td>PolS 271</td>
<td>U.S. Politics and the Environment</td>
<td>4</td>
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<tr>
<td>PolS 375</td>
<td>Seminar: Green Polity</td>
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Related Courses

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<th>Credits</th>
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<tr>
<td>Anth 1</td>
<td>Introduction to Anthropology</td>
<td>4</td>
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<tr>
<td>Anth/Clss 345</td>
<td>Evolution of the State</td>
<td>3</td>
</tr>
<tr>
<td>Jour/STS 124</td>
<td>Politics of Science</td>
<td>3</td>
</tr>
<tr>
<td>Jour 313</td>
<td>Special Topics in Science Writing (1-4)</td>
<td>3</td>
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<tr>
<td>PolS 115</td>
<td>Technology as Politics</td>
<td>4</td>
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<tr>
<td>PolS 177</td>
<td>Urban Politics</td>
<td>4</td>
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<tr>
<td>Rel 6</td>
<td>Religion and the Ecological Crisis</td>
<td>4</td>
</tr>
<tr>
<td>SSP 165</td>
<td>Contemporary Social Problems</td>
<td>3</td>
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[15 credits are required for the environment and society minor]

Environmental Science

See listings under Earth and Environmental Sciences

Environmental Writing

See listings under Journalism and Communication

Finance

Professor. Stephen G. Buell, Ph.D. (Lehigh).

Associate professors. James A. Greenleaf, Ph.D. (N.Y.U.) chair, department of finance and law; Richard J. Kish, Ph.D. (Florida); Stephen F. Thode, D.B.A. (Indiana); Geraldo M. Vasconcellos, Ph.D. (Illinois); Samuel C. Weaver, Ph.D. (Lehigh).

Assistant professor. Carolin D. Schellhorn, Ph.D. (Texas)


Visiting professor. Pamela A. Turner, Ph.D. (Alabama)

The finance major offered by the Department of Finance and Law requires 15 credit hours beyond the core requirements.

Each finance major selects either the business finance or financial economics track.

Business Finance

required courses:

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Fin 323</td>
<td>Investments</td>
<td>3</td>
</tr>
<tr>
<td>Fin 328</td>
<td>Corporate Financial Policy</td>
<td>3</td>
</tr>
<tr>
<td>plus two of the following:</td>
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<tr>
<td>Fin 324</td>
<td>Security Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Fin 330</td>
<td>Financial Flows and Markets</td>
<td>3</td>
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<tr>
<td>Fin 331</td>
<td>Bank Management</td>
<td>3</td>
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<tr>
<td>Fin 333</td>
<td>Multinational Business Finance</td>
<td>3</td>
</tr>
<tr>
<td>Fin 334</td>
<td>Derivative Securities Markets</td>
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<tr>
<td>Fin 335</td>
<td>Advanced Topics - Financial Management</td>
<td>3</td>
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<tr>
<td>Fin 336</td>
<td>Real Estate Finance</td>
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<tr>
<td>Fin 337</td>
<td>Advanced Topics - Investments</td>
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<tr>
<td>plus one additional 300-level finance or finance/economics course.</td>
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Financial Economics

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Undergraduate Courses

Fin 125. Introduction to Finance (3) fall, spring

An introductory finance course stressing the links between corporate finance and investments. Major topic areas will include financial statement analysis, time value of money, risk and return, valuation of stocks and bonds, capital budgeting, and cost of capital. Prerequisites: Eco 129, Eco 145, Math 51, Acct 151. Buell

For Advanced Undergraduates and Graduate Students

Courses numbered 200 and above in the College of Business and Economics are open to sophomores only on petition.

Fin 240. Introduction to Real Estate (3) spring

A survey of the four broad perspectives of real estate: legal, economic, financial, and business. Topics include: legal and physical rights to real estate; the nature and operation of real estate markets; valuation and appraisal of real estate; financing alternatives; and the real estate development process. Prerequisite: Fin 125/225 or permission of instructor.

Fin 323. Investments (3) fall, spring

The nature of risk and the form of returns to financial assets. Investor objectives, attitudes, and constraints are considered within the risk-return matrix as the basis for investment decisions. Problems of timing, market characteristics, and portfolio management. Prerequisite: Fin 125/225. Kish, Greenleaf

Fin 324. Security Analysis (3) fall

Factors influencing the value of financial securities: earnings forecasts and expectations, uncertainty, required returns, supply and demand for securities and funds, and investor attitudes.
Implications of market factors, technical approaches, timing, and screening. Prerequisites: Fin 323. Not ordinarily open to CBE graduate students.

**Fin 328. Corporate Financial Policy (3)** fall, spring
Advanced corporate finance; capital budgeting, working capital management, leasing, mergers, and financing. Case studies and/or complex problems. Prerequisite: Fin 125/225. Not ordinarily open to CBE graduate students. Thode, Kish, Weaver

**Fin 330. Financial Flows and Markets (3)** fall
Functions and portfolios of financial intermediaries. Sectoral demand and supply of funds, nature and role of interest rates, term structure and forecasting, impact of inflation and regulation on financial intermediaries and markets, and current developments in the financial system. Prerequisites: Eco 129/229 and Fin 125/225. Not ordinarily open to CBE graduate students. Schehellorn, Vasconcellos

**Fin 331. Bank Management (3)** spring
Management of bank assets and liabilities within the U.S. system's legal and economic constraints. Bank Management Simulator is used to examine relationships between asset, liability, and profitability decisions. Prerequisites: Eco 129/229 and Fin 125/225. Senior standing or consent of instructor. Not ordinarily open to CBE graduate students. Vasconcellos

**Fin 332. (Eco 332) Monetary-Fiscal Policy (3)**
Monetary, credit and fiscal policies of government and central banks, with particular reference to the policies of the United States Treasury and the Federal Reserve System. Prerequisite: Eco 119 or 129.

**Fin 333. Multinational Business Finance (3)** fall
Issues that underlie the investment, financing, and dividend decisions of multinational firms. Current transactions in foreign currencies, direct and portfolio investment and associated risk management when dealing in foreign countries. Prerequisite: Fin 328. Not ordinarily open to CBE graduate students. Vasconcellos

**Fin 334. Derivative Securities Markets (Options, Futures, etc.) (3)** spring
Theoretical and practical aspects of various instruments and markets that involve financial derivative instruments (options, futures, swaps, CMO's, etc.). Emphasis on applications to corporation finance and portfolio management. Prerequisite: Fin 332. Greenleaf

**Fin 335. Advanced Topics - Financial Management (3)**
Advanced topics relating to specific areas of corporate finance such as: bond refunding, asset valuation and capital budgeting including the role of uncertainty, imprecise forecasts, risk preferences, inflation, market conditions, and the global marketplace; working capital management, leasing, mergers, and financing. The course content may vary between instructors and over time, therefore, the course subject is change each time the course is offered. May be repeated. Prerequisite: Fin 328. Buell, Thode, Weaver

**Fin 336. Real Estate Finance (3)** fall
An advanced survey of modern residential and commercial real estate financing techniques from the perspectives of the borrower and the lender. Topics include: the principles of financing decisions; financing methods and techniques, institutional sources of funds for real estate, and real estate financing decision-making. The course includes lectures, demonstrations, spreadsheet software exercises, and guest speakers. Prerequisite: Fin 125/225. Thode

**Fin 340. (Eco 340) International Finance (3)**
Analysis of balance of payments and disturbances and adjustment in the international economy; international monetary policies. Prerequisite: Eco 129. Gunter
Five-Year Programs

Several ways exist for students to obtain two degrees in five years of study. See listings under Arts-Engineering; Civil Engineering and Geological Sciences; and Electrical Engineering and Engineering Physics.

Foreign Culture and Civilization

See listings under Modern Languages and Literature.

Foreign Literature

See listings under Classics and under Modern Languages and Literature.

French

See listings under Modern Languages and Literature.

Fundamental Sciences


The curriculum in fundamental sciences is designed to enable students to achieve a breadth of academic background in the fields of modern science and at the same time, through an option, to master the discipline of one of them, approximately to the level of a minimum bachelor's program. The options and electives provide sufficient flexibility to enable a student to prepare for employment in industry or government, for graduate study in a field, or for teaching mathematics or science at the secondary level. Fundamental science students are required to concentrate in a major.

The freshman year is identical with that of all students in the P.C. Rossin College of Engineering and Applied Science. The humanities and social science requirements of the college must also be satisfied. The discipline of a field will be provided by completing twenty-four semester hours in that field or from a combination of the fields. Examples of these combination fields include: biochemistry, geophysics, bioengineering, applied mathematics, biophysics, and computer science. Students pursuing double concentrations may, with the approval of their adviser, substitute for one of the science courses of the sophomore year a basic course in the area of concentration.

The details of the student's program are worked out by the student with the advice of the curriculum adviser.

Recommended Sequence of Courses

freshman engineering year (see Section III)

sophomore year, first semester (16 credits)
EES 31 Introduction to Environmental and Organic Biology (4) or
EES 21 Introduction to Earth Materials and Processes and Laboratory (4)
Chm 51, 53 Organic Chemistry and Laboratory (4)
Math 23 Analytic Geometry and Calculus III (4)
Eco 1 Principles of Economics (4)

sophomore year, second semester (17 credits)
major subject (3)
Math 205 Linear Methods (3)
Phys 21, 22 Introductory Physics II and Laboratory (5)
HSS elective (3)

junior year, first semester (17 credit hours)
EES 21 Introduction to Earth Materials and Processes and Laboratory (4) or
EES 31, 32 Introduction to Environmental/ Organismal Biology and Laboratory (4)
Psyc 1 Introduction to Psychology (4)
Math 231 Probability and Statistics (3)
major (3)
HSS elective (3)

junior year, second semester (15 credit hours)
approved electives (6)
major (6)
elective (3)

senior year, first semester (18 credit hours)
approved electives (6)
major (6)
HSS elective (3)
free elective (3)

senior year, second semester (18 credits)
Phil 128 Philosophy of Science (3)
approved elective (3)
major (6)
HSS elective (3)
free elective (3)

Geology

See listings under Earth and Environmental Sciences

German

See listings under Modern Languages and Literature.

Government

See listings under Political Science

Greek

See listings under Classics.

Hebrew

Modern Hebrew is taught in the Department of Modern Languages and Literature. Biblical Hebrew is taught in the Department of Religion Studies.
History

**Professors.** Jean R. Soderlund, Ph.D. (Temple), chairperson; Michael G. Baylor, Ph.D. (Stanford); Ian P. H. Duffy, D.Phil. (Oxford, England); Steven L. Goldman, Ph.D. (Boston), Andrew W. Mellon Distinguished Professor in the Humanities; Tom F. Peters, Dr. Sc. (Swiss Federal Institute of Technology, ETH Zurich); C. Robert Phillips, Ph.D. (Brown), Classics and Ancient History; James S. Saeger, Ph.D. (Ohio State); William R. Scott, Ph.D. (Princeton); Roger D. Simon, Ph.D. (Wisconsin).

**Associate professors.** Gail A. Cooper, Ph.D. (U.C., Santa Barbara); Stephen H. Cutchiffe, Ph.D. (Lehigh), History and STS; John K. Smith, Ph.D. (Delaware).

**Assistant professors.** John Pettigrew, Ph.D. (Wisconsin); Patricia Turner, Ph.D. (Michigan).


The history major introduces students to the study of the causes and consequences of change through an examination of political, economic, social, cultural, and intellectual developments and institutions over time. The department’s goal is to train its majors to think critically about the events and forces which have shaped the modern world, to analyze and interpret sources and evidence, and to view issues from a variety of perspectives. Those skills have served students well in a wide range of careers. Lehigh history majors have frequently gone on to law school or to work in various areas of education, journalism, and public affairs, but the majority have pursued a wide range of business occupations. The major also provides an excellent basis for graduate training in a wide range of public policy fields.

The department offers a program of independent research under the direction of an individual faculty member (History 391, 392). A maximum of six credits may be used toward this requirement. Normally students pursue their research in the second semester of the junior year and the first semester of their senior year; the project may also be undertaken during the senior year. Students who do well on their research project will graduate with department honors. The writing intensive requirement must be fulfilled by a course in the history department. For advanced placement, please see page 5.

The department recommends that students intending to major in history take Math 12, Basic Statistics, to fulfill their college math requirement.

### Department Major Requirements

A history major consists of 35 hours, normally nine courses, as follows:

- **Hist 11. Survey of Europe to 1648.**
- **Hist 12. Survey of Europe Since 1648.**
- **Hist 201. Historical Perspectives, or Hist 202, Historical Research.**
- One course in the history of Asia, Africa, or Latin America: Hist 5, 31, 49, 50, 75, 177, 341, 342, 359, 368.
- **Hist 104, 300, 303, 371, 391, 392, or provisional courses may be used to fulfill this requirement in accordance with their contents and emphases.**
- Minimum of 12 hours of courses numbered 303 or higher (except Hist 306).

### Requirements for Honors

Students wishing to graduate with honors must have 39 credits and must have completed History 391.

To graduate with a history major, a minimum 24 hours must be graded course work taken at Lehigh.

### History Minor Requirements

Each student's minor program is prepared in consultation with the advisor of minors in the history department. Advanced placement credit may not be used for the minor program.

- *four courses or 16 credits*
- *at least 4 credits at 200 or 300 level*
- *maximum of one course (4 credits) of transfer or cross-listed courses may count toward minor.*

### Undergraduate Courses in History

**Petitions are required for first-year students to take 100-level or higher courses, and for sophomores to take 200-level or higher courses.** **HU** - fills humanities distribution requirements; **SS** - fills social science requirements; **ND** - not designated, varies with course content.

**Hist 5. (AAS 5) African Civilization (4)**
Sub-Saharan Africa through the millennia of the ancient world to the present. Human origins, state and non-state systems, the external slave trade, colonialism, resistance to European rule, independence movements, and neocolonialism. **(SS)** Keim, Scott

**Hist 7. The Machine in America (3)**
American technology since colonial times. Changes in techniques and organization of processing, manufacturing, transportation and construction: consideration of social, cultural, and economic impact. **(SS)** Smith, Cooper

**Hist 11. Survey of Europe to 1648 (4)**
Fall
Development of European history from Rome to the 17th century. End of the ancient world, origins and growth of medieval civilization, the Renaissance and Reformation. **(HU)** Baylor

**Hist 12. Survey of Europe Since 1648 (4)**
Spring
The rise of modern nation states; the scientific and industrial revolutions; social movements and the French and Russian revolutions; impact of Enlightenment philosophy, nationalism, liberalism, imperialism and fascism; the development of modern class structure and transformations in gender relations, art, popular culture and society. **(HU)** Turner

**Hist 15. English History (4)**
The history of England to 1688. The origins of representative government, the development of English social institutions, the unification of England, and the Renaissance and Reformation in England. **(HU)** Duffy

**Hist 16. English History (4)**
English political and social institutions from 1688 to the present. The evolution of parliamentary government, the rise of modern parties, the industrial revolution, and recent social philosophies. **(HU)** Duffy

**Hist 21. (Clss 21) Greek History (3)**
The development of civilization from paleolithic times to the world empire of Alexander the Great. The social, economic, religious, philosophic, artistic, and literary development of the ancient world; the origin of political institutions. **(SS)** Phillips

**Hist 22. (Clss 22) Roman History (3)**
Rome from its origins to A.D. 476. Political, social and religious developments. Transformation of the late Roman Empire to the early medieval period. **(SS)** Phillips

**Hist 31. (Asia 31) History of Japanese Industrialization since 1800 (3)**
The late Tokugawa economic development, rise of an entrepreneurial class, importation of western technology, and
the rise of social, political, and economic institutions which support industrial growth. Students are encouraged to take Hist 32 consecutively. (SS) Cooper

Hist 32. Japanese Industrialization: Laboratory (1)
Directed study of an issue in history of Japanese industrialization. May only be taken concurrently with Hist 31. (SS) Cooper

Hist 41. United States to 1865 (3) fall
Native American cultures; European settlement; development of slavery and free labor systems; the Revolution; founding of the new nation; 19th century social, economic, cultural, and political development; Civil War. Students are encouraged to take Hist 44 concurrently. Not open to students who have taken Hist 9. (SS) Soderlund

Hist 42. United States, 1865-1941 (3) spring
America's transformation into an industrial and global power from Reconstruction after the Civil War to the Great Depression; includes social, political, and cultural developments. Students are encouraged to take Hist 45 concurrently. Not open to students who have taken Hist 10. (SS) Cooper, Simon, Smith

Hist 43. United States Since 1939 (3) spring
World War II; Cold War at home and abroad; Civil Rights movement; the 1960s: Vietnam, the welfare state and social upheavals; new forms of cultural expression; feminism; rise of neo-conservatism. Students are encouraged to take Hist 46 concurrently. Not open to students who have taken Hist 139. (HU) Pettegrew, Simon, Smith

Hist 44. United States to 1865; Laboratory (1)
Directed study of an issue in United States history to 1865. May only be taken concurrently with Hist 41. (SS)

Hist 45. United States 1865-1941; Laboratory (1)
Directed study of an issue in United States history, 1865-1941. May only be taken concurrently with Hist 42. (SS)

Hist 46. United States Since 1939; Laboratory (1)
Directed study of an issue in United States history since 1939. May only be taken concurrently with Hist 43. (HU)

Hist 49. History of Latin America (4)
Spanish and Portuguese colonization of America and the struggles for independence, preceded by a brief view of the ancient American civilizations and Iberian backgrounds. (SS) Saeger

Hist 50. History of Latin America (4)
Continuation of Hist 49. The development of the Latin American nations in the 19th and 20th centuries. (SS) Saeger

Hist 64. (AAS 64) Plantation to Ghetto (2)
Examination of topics in the economic history of African Americans from the 1500s to the present. Explores the slave trade, slavery, post-Civil War South, the black family, migration, urbanization, and race and poverty. (SS) O'Brien, Scott

Hist 75. (MLL 75, Asia 75) Chinese Civilization (4)
The development of traditional Chinese thought, beliefs, technology, and institutions from a historical perspective, from earliest times to China's encounter with the West. (HU) Pankener

Hist 104. Themes in History (2 - 4)
Seminar on a particular theme or topic not covered by a currently listed offering. (HU or SS depending on topic of seminar).

Hist 107. Technology and World History (4)
Development of technology and its relationship to political, economic, military and cultural aspects of world civilization from pyramids to the present. (SS) Smith

Hist 110. American Military History (4)
The American military tradition from colonial times to the present. America's wars and the development and operation of military institutions within the political, economic, ideological, and technological milieu of American society. Not open to students who have taken Hist 310. (SS) Saeger

Hist 111. Engineering in the Modern World (4)
Roles played by engineers and engineering in the modern world, focusing on major achievements and failures, prominent engineers, and evolution of the profession. (SS) Smith

Hist 120. Revolutionary America (4)
Origins and development of the American republic from 1750 through the adoption of the Federal Constitution. (SS) Soderlund

Hist 124. (WS 124) Women in America (4)
Roles of women in American society from colonial to present times: attitudes toward women, female sexuality, women's work, and feminism. (SS) Cooper, Soderlund

Hist 129. (AAS 129) Black Political Thought in America (4)
Black leadership, organizations, and philosophy in America from Reconstruction to the Civil Rights Era; ideas and programs of Booker T. Washington, W.E.B. DuBois, Marcus Garvey, Malcolm X and Martin Luther King, Jr. Scott. (SS)

Hist 130. (AAS 130) African American History (4)
Blacks in America from the first importation of Africans to the implementation of civil rights laws. West African origins, slave trade, slavery, free blacks and emancipation and study of Reconstruction, segregation, urbanization, and the struggle for racial equality. (SS) Scott

Hist 132. An Introduction to Canada (2)
A brief overview of major themes in Canadian history with emphasis on economic and political developments in the 19th and 20th centuries. (SS) Simon

Hist 135. Era of Jefferson and Jackson (4)
Colonial beginnings; the Articles of Confederation and the Constitution; the creation of a new nation; the development of American political parties; the antebellum American state. Not open to students who have taken Hist 335. (SS)

Hist 136. Era of the Civil War and Reconstruction (4)
American abolitionism and the origins of the Civil War, the Second American Revolution; Reconstruction and its sequel. (SS)

Hist 145. (STS 145) Introduction To the History of Science (4)
The history of modern science, primarily physical and biological, with emphasis on the development of major theoretical models since the 17th century. (SS) Goldman

Hist 150. Medieval Civilization (4)
Formation and development of western culture to about 1400. Rise of universities and towns, legal development and origins of representative government, origins of nation-states, scholasticism and decline of the medieval church. (HU)

Hist 152. (Clss 152/WS 152) Women in Antiquity (4)
Interdisciplinary study of women in Greece and Rome. Literary, archaeological and historical evidence and approaches. Cross-cultural material. (SS) Phillips

Hist 153. (WS 153) Women in European History, 1500-Present (4)
Examines the position of women in Europe since the Renaissance. Particular attention is given to changing conceptions of women and their roles in society, the evolution of women's work, the origins, growth and impact of feminism, and
gender distinctions as reflected in law, politics, popular culture and leisure. Not open to students who have taken WS 353/Hist 353. (SS) Turner

Hist 154. (Rel 154) The Holocaust: History and Meaning (4) spring
The Nazi Holocaust in its historical, political and religious setting. Emphasis upon the moral, cultural and theological issues raised by the Holocaust. (HU)

Hist 157. (Rel 157) The Renaissance and Reformation (4) Transition from medieval to early modern society: decline of medieval civilization; political, social and cultural changes of the Renaissance; the varieties of Protestantism; the wars of religion. (HU) Baylor

Hist 158. Early Modern Europe (4)
Transformation of European civilization from the 30 Years War to the outbreak of the French Revolution. Origins and development of the European state system; absolutism; commercial expansion and competition for empire; science; the Enlightenment and its impact on European culture and politics. (HU) Baylor

Hist 159. Revolutionary Europe, 1789-1870 (4)
Revolutions and reactions; the rise and spread of liberalism, nationalism, and socialism. (HU) Duffy

Hist 160. Europe in the Age of Total War, 1870-1945 (4)
Origins of two world wars; revolutionary governments in Germany, Italy, and Russia. (HU) Duffy

Hist 161. (Clls 161) Roman Law (4)
Examination of Roman legal systems from the Twelve Tables to the Digest of Justinian. Emphasis on development of legal concepts and their historical context. Readings in primary sources; lectures; discussion. (SS) Phillips

Hist 162. Contemporary Europe (4)
Development of European States since 1945; European Community; Soviet influence and collapse. (HU) Duffy

Hist 163. France Since 1789 (4)
France's tumultuous transformation from an absolutist monarchy to a modern democratic republic. Explores major cultural, social and economic changes, with particular attention given to industrialization and urbanization, gender and class, church and state relations, the French Left and France's unique contribution to modern philosophy, art and culture. (SS) Turner

Hist 177. (Asia 177, MLL 177) China Enters the Modern Age (4)
The collapse of the imperial order and China's agonizing transformation into a modern nation over the past 150 years. The impact of imperialism, war, radical social change, and protracted revolution on Chinese beliefs, values, and institutions. (HU) Pankenier

Hist 180. (Rel 180) Religion and the American Experience (4)
The historical development of major religious groups in this country from colonial times to the present. Their place in social and political life, and the impact of the national experience upon them. Emphasis on religious freedom and pluralism, and the church-state relationship. (HU)

For Advanced Undergraduates And Graduate Students
Graduate students may take 300 level courses, for which they receive 3 credits.

Hist 201. Historical Perspectives (4) spring
Methodologies and interpretations of Western historians from ancient times to the present. (HU) Baylor

Hist 202. Introduction to Historical Research (4)
An introduction to historical interpretation, research design, and methodology. Students will research and write a paper on a historical topic using secondary and primary sources. (SS)

Hist 303. Topics in History (2 - 4)
Intensive study in a particular area of history for advanced students. Topics may vary; may be repeated for credit with consent of department chairperson. (ND)

Hist 305. Public History (3-4)
An examination of the public role of history in modern society, with focus on issues facing historians in museums, historical societies, archives, historic preservation, the federal government, and other organizations in the public sphere. Not open to students who took Hist 205. (SS)

Hist 306. Internship in Public History (2-4)
Professionally supervised work in a museum, historical society, archive, or other historical agency. Written journal and/or report evaluating the experience is required. Permission of department chair required. May not be counted toward the major requirement of 12 hours of courses numbered 303 or higher. (ND)

Hist 307. History of American Industrial Technology (3-4)
Origin and evolution of American technology and industry from the 19th century to the present. Investigates dynamics of major industries in national and international contexts. (SS) Smith

Hist 312. (Clls 312) Decline and Fall of the Roman Empire (3-4)
Political, social, and economic history of the Roman Empire, A.D. 117-A.D. 565. Romanization of the provinces, diffusion of Christianity, and special attention to transformation to medieval period. Includes readings in translation of primary sources. (SS) Phillips

Hist 313. (Clls 313) Golden Age of Greek Democracy (3-4)
Greek history of the seventh through fifth centuries B.C. Emphasis on the contrasting political and social systems of Athens and Sparta with consideration of related economic and military history. Attention to art, gender, literature, religion. Discussion and lectures; papers. (SS) Phillips

Hist 314. (Clls 314) Age of Caesar and Christ (3-4)
Roman History of the first century A.D. Political, cultural, and socio-economic changes; special attention to the evolution of absolute power. Lectures, discussions, papers. (SS) Phillips

Hist 315. American Environmental History (3-4)
Relationship between Americans and their natural environment from the colonial period to the present: impact of European settlement, attitudes toward wilderness, role of technological development, rise of preservation and conservation movements, establishment of national parks, recent environmental protection legislation. (SS) Cutcliffe

Hist 319. Colonial America (3-4)
Founding and growth of colonies in North America through 1763. Emphasis on motives for settlement, Native American-European relations, and the economic, social, and political development of the British West Indies and mainland provinces. (SS) Soderlund

Hist 323. American Cultural History Since 1900 (3-4)
Development of American popular culture and media: popular press, Hollywood, radio, television, sports, and advertising, and the meanings these institutions have created in 20th-century United States. (HU) Pettegrew
Hist 325. (SSP 325, WS 325) History of Sexuality and the Family in the U.S. (3-4)
Changing conceptions of sexuality and the role of women, men, and children in the family and society from the colonial to the post-World War II era. Emphasis on the significance of socio-economic class and cultural background. Topics include family structure, birth control, legal constraints, marriage, divorce, and prostitution. (SS) Soderlund

Hist 326. (SSP 326) Social Class in American History (3-4)
Emphasis on the 19th and 20th century, focusing on: emergence of a white-collar middle class; condition and treatment of the poor and growth of the welfare state; conditions of industrial workers, struggle to organize unions and their later decline; indicators of social status and exclusion among the rich; changing distribution of income and wealth over time and extent of social mobility. (SS) Saeger

Hist 327. American Intellectual History to 1900 (3-4)
Emphasis on initial conceptions of America, religion in the colonies, political culture of the Revolution, romantic movement in art and literature, and reform and utopian movements of the 19th century. (HU) Pettigrew

Hist 328. American Intellectual History Since 1900 (3-4)
Social, literary, and political thought in the 20th century with emphasis on pragmatism and progressivism, maturation of American literary culture, ideas of American exceptionalism at mid-century, civil rights movement and feminism, neo-conservatism and recent trends. (HU) Pettigrew

Hist 331. (AAS 331) United States and Africa (3-4)
Reciprocal relationships between North Africa and the African continent from the slave trade in the 17th century to the 20th century Afrocentric movement; impact of Americans on the shaping of modern Africa, Pan-African relations; influence of African Americans on US policies toward Africa. (SS) Scott

Hist 332. (AAS 332) Slavery and the American South (3-4)
The emergence and demise of the "peculiar institution" of African American slavery in British North America and the Old South. African background; colonial beginnings; 19th century slave community; the ruling race and proslavery ideology; the death of slavery and its aftermath; slavery and freedom in a comparative context. (SS)

Hist 333. American City to 1900 (3-4)
Settlement and planning of colonial towns; role of towns in the revolutionary era; industrialization and relationship of economic and technological change to urbanization; establishment of urban institutions; Irish and German immigration; beginnings of suburbanization; downtowns and the creation of a civic culture. Required field trip. (SS) Simon

Hist 334. American City in the Twentieth Century (3-4)
Immigration; Progressive "reforms;" urban planning and zoning; impact of automobile and suburbanization; Depression and New Deal; public housing and racial ghettos; urban decline and "renewal." Required field trip. (SS) Simon

Hist 341. Mexico and Central America (3-4)
Emphasis on Mexico and Guatemala from the era of the Aztec through the wars of independence to the 20th century revolutions. (SS) Saeger

Hist 342. Argentina, Brazil and Chile (3-4)
Eighteenth-century Spanish imperial readjustments, independence, the emergence of new societies, 20th-century extremist movements, and the problems of developing nations. (SS) Saeger

Hist 343. English History, 1471-1660 (3-4)
England under the Tudor monarchy and the problems facing its successors culminating in the civil wars and Interregnum. Political, economic, intellectual and religious developments of the period. (HU) Duffy

Hist 344. English History 1660-1789 (3-4)
Constitutional monarchy from the Stuart Restoration to the French Revolution. English civilization in an age of oligarchy, especially the political, social, economic and intellectual sectors. (HU) Duffy

Hist 345. Victorian Britain (3-4)
Development of democracy, liberalism, religious ferment, industrialization, class conflict, socialism, and empire in Victorian Britain. (HU) Duffy

Hist 346. Great Britain in the 20th Century (3-4)
Effects of world wars, loss of great power status, economic decline, social conflict, welfare state, modern political parties, Irish problem in 20th century Britain. (HU) Duffy

Hist 347. Russia to 1855 (3-4)
Emergence of Russian autocracy; impact of the Mongol invasions; Westernization and transformation of society and culture; economic development toward emancipation of the serfs. (HU)

Hist 348. Russia Since 1855 (3-4)
Russia in the context of European history: emancipation of the serfs and impact upon political, social, economic development; reasons for the growth of revolutionary pressure; collapse of autocracy; the revolutions of 1917; the Soviet era and the collapse of the Soviet Union. (HU)

Hist 349. Revolutions in Modern European History (3-4)
Explores the origins, meanings, and impact of European revolutions from a theoretical and comparative perspective. Focuses on the English (1642-1660), the French (1789-1799), and the Russian Revolution (1917-1929), and how they reflected and shaped new ideologies and policies related to human rights, economic development, popular sovereignty, nationalism, class and gender politics, and State and society relations. (SS) Turner

Hist 355. (Rel 355) European Cultural History I (3-4)
Major developments in European culture from the late Middle Ages through the 17th century. Late scholasticism, humanism and the Renaissance, varieties of Protestantism, origins of modern science. (HU) Baylor

Hist 356. European Cultural History II (3-4)
Transformation of European culture from the 18th century to the present. The Enlightenment, cultural impact of the French and industrial revolutions, romanticism and ideologies of the 19th century, contemporary European thought. (HU) Turner

Hist 357. Early Modern Germany, 1500-1850 (3-4)
The emphasis will be on one or more of the following topics: the Reformation, the Thirty Years' War and its impact, absolutism, the rise of Prussia, the failure of German liberalism. (HU) Baylor

Hist 358. Modern Germany, 1850 to Present (3-4)
Focus on one or more of the following topics: nationalism and unification, the Second Empire, World War I, the Weimar republic, the Nazi movement, the Third Reich, and post-war Germany. (HU) Baylor

Hist 359. (AAS 359) History of South Africa (4)
South Africa's history from its earliest human settlement to its emergence as a racist political order and transition to a non-racial democratic state. Includes comparisons with political thought and practices in the U.S. (SS) Scott
Hist 360. American Legal History (3-4)
The interrelationship between law and social development with emphasis on modern period. Founding of constitutional government and balance of power within the federal system, the problem of slavery, legal support and regulation of business, and the use of law in various reform and civil rights movements. (SS) Pettigrew

Hist 361. (Arch 361) Evolution of Highrise Building Construction (3)
The new materials iron and concrete led to new ways of thinking about building. The Industrial Revolution initiated the development of our modern culture of building and our current urban society. (HU) Peters

Hist 363. (Arch 363) Evolution of Long-Span Bridge Building (3)
New materials, forms of education and technology contributed to advanced structural understanding. Specialization and the rise of technological thinking led to new bridge types and increasing span size. (HU) Peters

Hist 365. (Arch 365) Evolution of the Modern Building Process (3)
The criteria of trade—time and money—entered the world of building in the 19th century. The unplanned interlude between the design and the inauguration of a building became a new professional field: the building process. (HU) Peters

Hist 368. Seminar in Latin American History (3-4)
Readings and individual investigation of selected topics. (SS) Saeger

Hist 371. Independent Study (1-4)
Directed readings in a topic or area of history not covered by current course offerings. For students of demonstrated ability and adequate preparation. Prerequisite: consent of department chair. May be repeated for credit with permission up to a maximum of six credits. (ND)

Hist 391. Honors Thesis in History (4)
Opportunity for undergraduate majors in history or American studies to pursue an extended project for senior honors. By invitation and department permission only. (ND)

Hist 392. Honors Thesis in History (2)
Continuation of History 391 available under exceptional circumstances where additional credit for honors project is warranted. Department permission only. (ND)

GRADUATE WORK IN HISTORY
Lehigh University has been granting advanced degrees in history for more than half a century. Its graduates have become university and college professors, secondary school teachers and administrators, museum directors, and public servants. The graduate program focuses primarily on the areas in which the department is particularly strong in faculty and resources, notably Colonial America and the history of technology and science. The department works closely with the Lawrence Henry Gipson Institute for Eighteenth Century Studies which sponsors yearly symposi a and provides research support for both faculty and students. The history of technology program is closely tied to Lehigh's Science, Technology, and Society program.

Lehigh's libraries are especially rich in materials for graduate research in history, particularly in the fields listed above. It has an extensive collection of scholarly periodicals and monographs. Graduate programs provide intensive and specialized study, and the policy of limited enrollment permits close relations between faculty and students.

Admission to graduate study in history is competitive and dependent upon the applicant's undergraduate preparation and record, recommendations, and Graduate Record Examination scores. Besides general requirements for the Graduate School, the following special requirements apply to graduate study in history.

Master of Arts
There are two masters programs. Under Plan I, a candidate may earn the degree by successfully completing 27 hours of approved course work and submitting a thesis of the length and quality that would make it suitable for publication as a scholarly article. The paper may be based on the dissertation research in the program. Candidates continuing toward a doctorate should select Plan I. Candidates declaring Plan II take 30 hours of approved course work and pass examinations in two fields chosen from American, British, European and Latin American history, and History of Technology. Candidates in either plan are required to maintain a 3.0 average in all graduate work and to take History 401 and History 404 or 405.

Doctor of Philosophy
Students in the Ph.D. program in history must maintain a 3.25 average. During the second semester, doctoral students select one major and three minor fields in which to take comprehensive written and oral examinations. The dissertation will be in the major field. The dissertation advisor will chair a special committee that will oversee the student's graduate program. The other members of the special committee will be those faculty who are examiners in the selected fields and one professor from another department relevant to the candidate's major field. No professor may direct more than one field, but the direction of the field may involve two professors. An original dissertation is required and may be written only in the major field. It must be successfully defended to the examining committee.

All Ph.D. students must spend at least one year in residency as a full time student at Lehigh. They must take Historical Research (401) or, if they completed Hist 401 or its equivalent at the M.A. level, a 450-series research seminar. Students who enter the Ph.D. program with an M.A. from another university must also take either Readings in the History of the Atlantic World (404) or Readings in the History of Industrial America (405). Students are encouraged to take both seminars if appropriate to their course of study. All Ph.D. students must take at least 18 hours of directed readings courses (440 series) beyond the M.A.

Major Fields. Major fields are Technology, Modern Britain, Colonial America, Nineteenth Century United States, Twentieth Century United States. (The Nineteenth and Twentieth century fields may be divided topically rather than chronologically; for example, a student may be examined in labor/social history 1800-present, and in political history 1800-present.)

Minor Fields. Any of the major fields listed above may also be minor fields. Other minor fields may be Ancient History; Early Modern Europe; Modern Europe; Latin America; Environmental History; Science, Technology and Society studies.

Language requirements. The student's special committee determines whether proficiency in a foreign language or proficiency in statistical methods will be required for the doctoral degree. More detailed regulations are given in the Handbook for Graduate Work in History, available in the history department office.

GRADUATE COURSES IN HISTORY
Hist 401. Historical Research (3)
Techniques of research in history: training in the critical handling of documentary materials, in measuring the value of evidence, and in formal presentation of the results of research. Students will write an original research paper using primary materials. Required of all graduate students in history.

Hist 404. Readings in the History of the Atlantic World, 1500-1900 (3)
Core readings offering a comparative and integrative approach to studying the development of nations, economic systems and trade, colonization, and cultural encounters among the people of Europe, Africa, and the Americas.
Hist 405. Readings in the History of Industrial America (3)
Core readings in the history of technology and the larger framework of intellectual, social, economic, and political history. Includes comparative studies in the history of industrializing Europe and Japan.

Hist 407. Seminar in the History of American Industrial Technology (3)
Origin and evolution of American technology and industry from the 19th century to the present. Investigates dynamics of major industries in national and international context. Not open to students who have taken Hist 307. Smith

Hist 440. Readings in Colonial American History (3)
Study in small groups under the guidance of a faculty member of the literature of the 17th and 18th centuries. May be repeated for credit with the permission of the faculty advisor.

Hist 441. Readings in Nineteenth Century American History (3)
Study in small groups under the guidance of a faculty member of the literature of the 19th century. May be repeated for credit with the permission of the faculty advisor.

Hist 442. Readings in Twentieth Century American History (3)
Study in small groups under the guidance of a faculty member of the literature of the 20th century. May be repeated for credit with the permission of the faculty advisor.

Hist 443. Readings in English History (3)
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem, or area of English history. May be repeated for credit with permission of the faculty advisor.

Hist 444. Readings in Latin American History (3)
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem, or area of Latin American history. May be repeated for credit with permission of the faculty advisor.

Hist 445. Readings in the History of Science (3)
Study in small groups under the guidance of a faculty member on the history of science. May be repeated for credit with permission of the faculty advisor.

Hist 446. Readings in the History of Technology (3)
Study in small groups under the guidance of a faculty member of the history of technology. May be repeated for credit with the permission of the faculty advisor.

Hist 447. Readings in European History (3)
Study in small groups, under the guidance of a faculty member of the literature of a particular period, problem or aspect of European history. May be repeated for credit with permission of the faculty advisor.

Hist 452. Research in American History (3)
An intensive research seminar on a phase of American history. May be repeated for credit with permission of the department chair.

Hist 453. Research in English History (3)
An intensive research seminar on a phase of English history. May be repeated for credit with permission of the department chair.

Hist 454. Research in Latin American History (3)
An intensive research seminar on a phase of Latin American history. May be repeated for credit with permission of the department chair.

Hist 455. Research in History of Science and Technology (3)
An intensive research seminar on a phase or aspect of the history of science and technology. May be repeated for credit with permission of the department chair.

Hist 457. Research in European History (3)
An intensive research seminar on a phase of European history. May be repeated for credit with permission of the department chair.

Hist 471. Special Topics in History (1-3)
Individual study under the direction of a faculty member of a topic in history. May be repeated for credit.

Hist 472. Special Topics in History (1-3)
Individual study under the direction of a faculty member of a topic in history. May be repeated for credit.

Industrial and Manufacturing Systems Engineering

Professors. Keith M. Gardiner, Ph.D. (Manchester); Mikell P. Groover, Ph.D. (Lehigh); Louis A. Martin-Vega, Ph.D. (Univ. of Florida) chair; Nicholas G. Odrey, Ph.D. (Penn State); G. Sathyarayanan, Ph.D. (Michigan Tech); Emory W. Zimmers, Jr., Ph.D. (Lehigh).

Associate professors. Laura I. Burke, Ph.D. (California-Berkeley); Robert H. Storer, Ph.D. (Georgia Tech); Louis J. Plebani, Ph.D. (Lehigh); Gregory L. Tonkay, Ph.D. (Penn State); George R. Wilson, Ph.D. (Penn State); Szu-Yung David Wu, Ph.D. (Penn State).

Assistant professor. Joseph C. Hartman, Ph.D. (Georgia Tech).
Emeritus professor. John W. Adams, Ph.D. (North Carolina)

Mission Statement
To pursue excellence and national prominence in the areas of manufacturing, operations research, information technology and related fields of industrial engineering through innovative teaching, distinguished research and scholarship, and active professional leadership. Building on its unique strength and national reputation in undergraduate education and industrial research, the department strives for leadership in educational innovation, multidisciplinary research, and industrial partnership. Our ultimate mission is to produce leaders who have learned to think critically and analytically, have the skills and techniques to comprehend and create new knowledge, and are willing to serve and inspire others.

Industrial engineering (IE) is concerned with the analysis, design, and implementation of integrated systems of people, materials, information, and equipment to accomplish useful work. The discipline of industrial engineering is applicable in nearly all industries, whether the industry involves manufacturing of a product or delivery of a service. Job functions performed by IEs include: methods analysis, work measurement, cost estimation, equipment selection, engineering economy, facilities planning, production planning and scheduling, inventory control, quality control, information systems, project management, operations management, and engineering management. Manufacturing systems engineering (MSE) is a specialty field associated with industrial engineering that emphasizes functions and technologies such as process planning, plant layout design, manufacturing resource planning, production management, production line design, automation, robotics, flexible manufacturing systems, and computer integrated manufacturing.
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Career Opportunities
IE graduates are sought by nearly all industrial corporations as well as government agencies and other service institutions. In addition to the manufacturing industries, which traditionally hire IEs, other employers of our graduates include management consulting firms, banks, hospitals, railroads, the postal service, and private parcel delivery services. A typical career path of an industrial engineer is to start in an entry level engineering position or line supervision, and to progress through various management positions in the firm or institution. Significant numbers of industrial engineers ultimately become chief executive officers in their respective organizations.

The Curriculum
The IE curriculum is designed to provide graduates with the skills and knowledge that employers expect of young industrial engineers beginning their professional careers. It includes the basic mathematical, physical, and social sciences, together with the principles and methods of engineering analysis and design that are specific to industrial engineering. These principles and methods include probability and statistics, engineering economy, cost accounting, operations research, work methods and measurement, manufacturing processes, production and inventory control, and information systems.

Specialized industrial engineering electives in the senior year include: advanced operations research, discrete event simulation, organization planning and control, statistical quality control, database design, and data communications technologies. Electives related to manufacturing systems engineering include: computer integrated manufacturing, industrial robotics, facilities planning and material handling, production engineering, and metal machining analysis.

Physical Facilities
The industrial and manufacturing systems engineering department is located in the Harold S. Mohler Laboratory at 200 West Packer Avenue at the northwest corner of the Lehigh University Asa Packer campus. The Mohler Lab building contains the classrooms, laboratories, and faculty offices of the department. Labs in the Mohler Laboratory building include:

Computer Integrated Manufacturing (CIM) Laboratory: The CIM lab contains a variety of computer systems and software that includes computer-aided design and engineering (CAD and CAE), numerical control part programming, discrete event simulation, facilities design, process design, and process control.

Manufacturing Technology Laboratory (MTL): The MTL contains equipment for instruction and research in manufacturing processes, numerical control (NC), NC part programming, material handling and storage, industrial control systems, and metrology.

Robotics and Automation Laboratory: This lab contains a variety of industrial robots and other automated systems to provide students with hands-on experience in the planning and use of this kind of equipment.

Electronics Manufacturing Laboratory (EML): The EML contains equipment for instruction and research in electronics assembly, soldering, screen printing, inspection, and other processes associated with printed circuit card fabrication and assembly.

Work Systems Laboratory: This classroom-laboratory affords the opportunity for undergraduate students to analyze and plan human work activities for individual workstations and worker teams. A full-scale manual assembly line is available for study.

Considerable use is made of university computer facilities in IE coursework. An IE/computing center PCLaboratory containing 15 PCs and a workstation laboratory containing 4 UNIX workstations is located in the Mohler Laboratory building.

Specialty Areas in Industrial Engineering
The industrial and manufacturing systems engineering department at Lehigh University emphasizes four areas in its undergraduate program: (1) manufacturing systems and processes, (2) operations research, (3) information systems, and (4) production and operations management. The I&MSE curriculum includes 15 credit hours of advanced (300 IE level) courses plus six credit hours of free electives. Students can emphasize one of these areas if they choose, or select courses from several areas to design their own individual programs. Listed below are the advanced courses associated with the four specialty areas (includes courses in other departments). Senior I&MSE majors can also petition to take up to two graduate (400 IE level) courses to meet their program requirements.

Manufacturing Systems and Processes. Students specializing in this area should select 300-level courses from the following list:

IE 319  Material Handling and Facilities Planning (3)
IE 324  Industrial Robotics (3)
IE 332  Quality Control (3)
IE 340  Production Engineering (3)
IE 342  Computer Integrated Manufacturing (3)
IE 344  Metal Machining Analysis (3)
IE 345  Manufacturing Information Systems (3)
Mat 309  Composite Materials
Mat 314  Advanced Metal Forming (3)
Mat 335  Principles of Semiconductor Materials Processing (3)
Mat 342  Inorganic Glasses (3)
Mat 367  Metal Films and Coatings: Processing Structure and Properties (3)
*IE 344  crosslisted with Mat 344

Operations Research. Students specializing in this area should select 300-level courses from the following list:

IE 316  Advanced Operations Research (3)
IE 332  Quality Control (3)
IE 339  Queuing Theory (3)
CSc 327  Artificial Intelligence Theory and Practice (3)
CSc 340  Design and Analysis of Algorithms (3)
Math 312  Applied Statistics (3)
Math 338  Regression Analysis (3)
Math 341  Mathematical Models and Their Formulation (3)
ME 340  Advanced Mechanical Design (3)

Information Systems. Students specializing in this area should select 300-level courses from the following list:

IE 307  Advanced Systems Analysis and Design (3)
IE 309  Introduction to Information Systems (3)
IE 310  Database Analysis and Design (3)
IE 316  Advanced Operations Research (3)
IE 341  Data Communication Systems Analysis and Design (3)
IE 342  Computer Integrated Manufacturing (3)
IE 343  Microprocessor Systems in IE (3)
IE 345  Manufacturing Information Systems (3)
CSc 327  Artificial Intelligence Theory and Practice (3)
CSc 340  Design and Analysis of Algorithms (3)
CSc 368  Artificial Intelligence Programming (3)
ECE 319  Digital Signal System Design (3)
ECE 320  Logic Design (3)
ECE 345  Speech Synthesis and Recognition (3)

Production and Operations Management. Students specializing in this area should select 300-level courses from the following list:

IE 319  Material Handling and Facilities Planning (3)
IE 324  Industrial Robotics (3)
IE 332  Quality Control (3)
IE 334  Organizational Planning and Control (3)
IE 340  Production Engineering (3)
IE 342  Computer Integrated Manufacturing (3)
Mgt 309  Industrial Purchasing and Materials Management (3)
Mgt 331  Industrial Relations and Public Policy (3)
Mgt 333  Personnel Management (3)
Special Opportunities
The following special opportunities are available to majors in industrial and manufacturing systems engineering:

**Nontechnical minor.** Students may choose to pursue a nontechnical minor in an area of the humanities and social sciences. The minors program section of this catalog should be consulted for details. Possible minors include classics, economics, history, international relations, philosophy, and psychology. Most nontechnical minors require 15 credit hours of coursework in the department, which can usually be satisfied within the 21 total credit hours of humanities, social sciences, and free electives available in the IMSE curriculum.

**Technical minor.** Technical minors such as materials science and computer science are available through other departments in the P. C. Rossin College of Engineering and Applied Science. Consult the specific department for more details.

**Graduate courses.** Seniors in industrial and manufacturing systems engineering can petition to take up to two graduate IE courses (400-level) to satisfy two of their five 300-level IE course requirements. The petitioning senior must have a good scholastic record (generally above a 3.0 GPA).

Technical Minor in Manufacturing Systems Engineering
The minor in manufacturing systems engineering provides a concentration of courses in the manufacturing and production areas. This minor is not available to students in the IMSE concentration of courses in the manufacturing and production sciences. The minors program section of this catalog should be consulted for details. The petitioning senior must have a good scholastic record (generally above a 3.0 GPA).

5 Year BSIE/Master of Management Science Option
Students enrolled in the IMSE curriculum can pursue a five-year BSIE/Master of Management Science program. Students in the management science program take a mixture of engineering and business courses. Admission is not guaranteed. For details see the management science section of the catalog or contact the IMSE department.

Major Requirements
See freshman year requirements, section III.

**sophomore year, first semester (16 credit hours)**
- IE 111 Engineering Probability and Statistics (3)
- IE 112 Computer Graphics (1)
- Math 23 Calculus III (4)
- Phy 21, 22 Introductory Physics II and Laboratory (5)
- Mat 33 Engineering Materials and Processes (3)

**sophomore year, second semester (17 credit hours)**
- IE 121 Applied Engineering Statistics (3)
- IE 122 Software Tools (1)
- IE 131 Work Systems and Facilities Planning (3)
- IE 132 Work Systems Laboratory (1)
- ME 104 Thermodynamics I (3)
- Acct 108 Fundamentals of Accounting (3)
- Humanities / Social Sciences elective (3)

**junior year, first semester (17 credit hours)**
- IE 115 Fundamentals of Modern Manufacturing (3)
- IE 116 Manufacturing Laboratory (1)
- IE 221 OR - Probabilistic Models (3)
- Math 205 Linear Methods (3)
- Mech 2 Elementary Engineering Mechanics (3)
- Eco 1 Principles of Economics (4)

**junior year, second semester (16 credit hours)**
- IE 124 Engineering Economy (3)
- IE 222 OR - Deterministic Models (3)
- IE 224 Information Systems Analysis and Design (3)
- ECE 81 Principles of Electrical Engineering (4)
- IE 305 Simulation (3)

**senior, first semester (18 credit hours)**
- IE 251 Production and Inventory Control (3)
- IE elective (3)*
- IE elective (3)*
- IE elective (3)*
- Humanities / Social Sciences elective (3)
- Free elective (3)

**senior, second semester (18 credit hours)**
- IE 154 senior project (3)
- IE elective (3)*
- IE elective (3)*
- Humanities / Social Sciences elective (3)
- Humanities / Social Sciences elective (3)
- Free elective (3)

Notes:
*IE elective courses are chosen from the current offering of 300-level IE courses.
**The engineering elective is any course offered in the CEAS that IE undergraduates are eligible to take.

Undergraduate Courses

**IE 100. Industrial Employment (0)**
Usually following the junior year, students in the industrial engineering curriculum are required to do a minimum of eight weeks of practical work, preferably in the field they plan to follow after graduation. A report is required. Prerequisite: Sophomore standing.

**IE 111. Engineering Probability and Statistics (3) fall**
Random variables, probability models and functions, and expected values. Statistical inference, estimation, hypothesis testing, and goodness of fit. Prerequisite: Math 22.

**IE 112. Computer Graphics (1) fall**
Introduction to interactive graphics and construction of multi-view representations in two- and three-dimensional space. Applications in industrial engineering. Prerequisite: Sophomore standing in industrial engineering, Engr. 1.

**IE 115. Fundamentals of Modern Manufacturing (3) fall**
Study of modern production methods. Machining and other metal working processes, electrical and electronics manufacturing, and nontraditional processing. Introduction to automation, numerical control, and industrial robots. Prerequisite: Mat 33.

**IE 116. Manufacturing Laboratory (1) fall**
Laboratory exercises and experiments in manufacturing processes and systems. Co-requisite: IE 115.

**IE 121. Applied Engineering Statistics (3) spring**
The application of statistical techniques to solve industrial problems. Topics include regression and correlation, analysis of variance, quality control, and reliability. Prerequisite: IE 111 or Math 231.

**IE 118. Software Tools (1) spring**
Introduction to software tools, including word processing, spreadsheets, and statistical packages. Problems for solution will be drawn from other courses in the sophomore program. Prerequisite: Engr. 1; IE 121, previously or concurrently.

**IE 124. Engineering Economy and Decision Analysis (3) spring**
Economic analysis of engineering projects; interest rate factors, methods of evaluation, depreciation, replacement, break-even
study of information systems analysis and design with emphasis on management issues. Interfaces between information systems and databases and data communications are examined. Effects of information systems on organizational relationships are considered. Example information system will be designed and implemented. Prerequisite: IE 224 or equivalent.

IE 310. Database Analysis and Design (3) spring
Conceptual analysis of data is considered through data structures and models. Logical design of databases is studied in the context of the relational model of data. Prerequisite: IE 224 or equivalent.

IE 316. Advanced Operations Research Techniques (3)
A survey of advanced topics in operations research. Topics include advanced linear programming, dynamic programming, integer programming, decision analysis, game theory and nonlinear programming algorithms. Prerequisites: IE 221 and IE 222.

IE 319. Material Handling and Facilities Planning (3)
Material handling systems, storage systems and automatic identification. Facilities planning including layout planning and facility location. Prerequisite: IE 131 or consent of department chair.

IE 321. Experimental Industrial Engineering (1-3)
Experimental projects in selected fields of industrial engineering, approved by the instructor. A written report is required. May be repeated for academic credit.

IE 324. Industrial Robotics (3)
Introduction to robotics technology and applications. Topics include robot anatomy, controls, sensors, programming, work cell design, part handling, welding, and assembly. Laboratory exercises. Prerequisites: Mech 2, Math 205.

IE 328. Engineering Statistics (3)
Random variables, probability functions, expected values, statistical inference, hypothesis testing, regression and correlation, analysis of variance, introduction to design of experiments, and fundamentals of quality control. Prerequisite: Math 23 or equivalent. This course cannot be taken by IE undergraduates.

IE 332. Product Quality (3)
Introduction to engineering methods for the monitoring control and improvement of product quality. Topics include statistical models of quality measurements, statistical process control, acceptance sampling, and quality management principles. Some laboratory exercises. Prerequisite: IE 121.

IE 334. Organizational Planning and Control (3) fall
Design of organization and procedures for managing functions of industrial engineering. Analysis and design of resources planning and control, including introduction of change in man-machine systems; manpower management and wage administration. Prerequisite: IE 131 or 168.

IE 339. Queuing Theory (3)
Models for analyzing waiting lines and congestion systems. Methods and techniques for formulating Markov and non-Markov queues, networks, and approximation techniques. Prerequisite: course in probability theory.

IE 340. Production Engineering (3) fall

IE 341. Data Communication Systems Analysis and Design (3)
An introduction to the hardware as well as performance evaluation of data communication networks. Emphasis on data transmission, encoding, data link control, communication
IE 342. Computer Integrated Manufacturing (3) spring
Analysis and design of manufacturing systems using digital computers. Principal topics: computer-aided techniques, group technology, applications of minicomputers to manufacturing systems. Introduction to adaptive control, numerical control, and optimization strategies for discrete parts manufacturing. Term project. Prerequisite: IE 224, IE 115 or equivalent.

IE 343. Microprocessor Systems in IE (3) fall
Fundamentals of microprocessors and microcomputers for industrial engineering applications. Topics include basic digital concepts, microprocessor programming interfacing, data acquisition and system development for timing, counting, decision making and control. Laboratory. Prerequisites: IE 224 and IE 115 or equivalent.

IE 344. (Mat 344) Metal Machining Analysis (3) spring
Intensive study of metal cutting emphasizing forces, energy, temperature, tool materials, tool life, and surface integrity. Abrasive processes. Laboratory and project work. Prerequisite: IE 115 or ME 240 or Mat 206.

IE 345. Manufacturing Information Systems (3)
This course examines the foundations for information systems required to support the manufacturing function throughout the product life cycle. Students will be exposed to the problems of design, implementation, and management by way of assigned readings, class discussion of cases, and a research project.

Graduate Programs
Several programs leading to master's and doctoral degrees are offered by the Department of Industrial and Manufacturing Systems Engineering. All IMSE graduate students are required to satisfy core requirements in manufacturing and operations research. To satisfy the core requirement in manufacturing, the student must complete either IE 340 or IE 342. To satisfy the core requirement in operations research, the student must complete either IE 305 or IE 316. Core requirements may also be satisfied by previous coursework. In this case, the student must petition the IMSE graduate committee to waive the core requirement in the relevant area. All core course prerequisites must also be satisfied. Prerequisites may be satisfied by (1) previous course work, (2) completing the prerequisite course without graduate credit, or (3) passing the final examination of the prerequisite course with a grade of B or better.

A Ph.D. student is required to complete core requirements with grades of B or better before being formally admitted to Ph.D. candidacy. Further information about graduate programs is contained in an IMSE graduate brochure available from the department. In addition, several documents are available from the department that describe the requirements for each of our graduate programs.

M.S. in Industrial Engineering
The minimum program for the master of science degree in IE consists of 24 credit hours of approved coursework and completion of a satisfactory thesis. Courses in other departments for which the student has the prerequisites may be integrated into the MSIE program. Subject to advisor approval, up to nine credit hours of 300 and 400-level courses from other departments may be included in the IE masters program. The other department courses usually include other engineering disciplines, mathematics, computer science, and business and economics.

M.Eng. in Industrial Engineering
This program of study is for those students whose interests are toward engineering design rather than research. The program provides opportunity to gain breadth of field by required coursework in all areas of study within the department. In addition, an engineering project must be completed under the supervision of the faculty.

M.S. in Management Science
This program requires a minimum of 30 credit hours of approved coursework. The program leads to the master of science degree in management science. See separate catalog listing under Management Science.

M.S. in Manufacturing Systems Engineering
This is an interdisciplinary graduate program leading to the master of science degree in manufacturing systems engineering. See separate catalog listing under Manufacturing Systems Engineering.

M.S. in Quality Engineering
This is a specialized graduate program offered by the Department of Industrial and Manufacturing Systems Engineering leading to the master of science degree in quality engineering. See separate catalog listing under Quality Engineering.

Ph.D. in Industrial Engineering
The graduate program leading to the doctor of philosophy (Ph.D.) degree is organized to meet the individual goals and interests of graduate students whose professional plans include teaching, consulting, or research in an educational, governmental, or industrial environment. Each doctoral candidate is required to demonstrate: (1) a high level of proficiency in one or more fields of industrial and manufacturing systems engineering, and (2) a capacity for independent research through the preparation of a dissertation related to his/her field of specialization.

Areas of Graduate Study
The areas of graduate study emphasized in the Department of Industrial and Manufacturing Systems Engineering are as follows:
Manufacturing Systems and Processes. Graduate study in manufacturing involves coursework and research in any of a variety of subjects, including manufacturing processes, automation, robotics, numerical control, computer integrated manufacturing, process control, material handling, and production scheduling. In manufacturing processes, the department specializes in the material removal processes, such as machining (e.g., turning, milling, drilling, grinding) and nontraditional processes (e.g., water jet cutting, electrochemical machining). Additional manufacturing process technologies are covered in other departments in the P. C. Rossin College of Engineering and Applied Science, in particular, the materials science and engineering department.

Operations Research. The operations research graduate area is intended to prepare students to analyze, formulate, and solve problems using analytical methods and computational techniques. Topics emphasized in the department include mathematical programming, combinatorial optimization, queuing theory, neural networks, and stochastic processes. There are many settings in which operations research problems are encountered, but those which arise in the context of manufacturing are of particular interest to the Department of Industrial and Manufacturing Systems Engineering. Students can expect to study challenging problems at both the master's and doctoral levels.

Information Systems. Graduate study in information systems covers the methodological and technological development of
computer information systems. Of particular interest at Lehigh are the systems needed to drive integrated manufacturing and service industries. Such systems are becoming increasingly important in the trend toward real-time planning and control, with embedded decision making capabilities. Topics include data communication, telecommunication and computer networks, database processing systems, artificial intelligence and expert systems, object-oriented technology, and computer-based production planning and inventory control. The information systems area is further supplemented by courses offered by the Department of Electrical Engineering and Computer Science.

IE 405. Special Topics in Industrial Engineering (3)
An intensive study of some field of industrial engineering.

IE 408. Management of Information Systems (3)
Philosophies and methods for systematic planning, development, and implementation of management information systems. Concepts of information resource management, and strategic and long-range planning of information systems and services. Prerequisite: IE 224 or Act 311 or equivalent.

IE 409. Data Dependent Systems (3)
Theory and applications of an approach to process modeling, analysis, prediction, and control based on an ordered sequence of observed data. Single or multiple time series are used to obtain scalar or vector difference/differential equations describing a variety of physical and economic systems. Prerequisite: IE 121 or equivalent.

IE 410. Design of Experiments (3)
Experimental procedures for sorting out important causal variables, finding optimum conditions, continuously improving processes, and trouble shooting. Applications to laboratory, pilot plant and factory. Prerequisite: Some statistical background and experimentation in prospect, IE 121 or equivalent.

IE 411. Networks and Graphs (3)
This course examines the theory and applications of networks and graphs. Content of the course stresses on the modeling, analysis and computational issues of network and graph algorithms. Topics include: complexity theory, trees and arborescences, path algorithms, network flows, matching and assignment, primal-dual algorithms, Eulerian and Hamiltonian walks and various applications of network models. Prerequisite: IE 316 or equivalent.

IE 415. Manufacturing Management (3)
Analysis of the factors entering into the development of manufacturing management philosophy, decision-making process in areas of organization, planning, production, and control of manufacturing, influence of the social, technical, and economic environment upon manufacturing management decisions.

IE 416. Dynamic Programming (3)
The principle of optimality and recursive solution strategy; multidimensional problems; reduction of dimensionality and approximation; stochastic control; non-serial systems; relationship to calculus of variation; applications. Prerequisite: IE 316 or equivalent.

IE 417. (GBUS 452) Advanced Mathematical Programming (3)
Theoretical and algorithmic structure of optimization methods; search strategies for unconstrained optimization; conditions for constrained optima; algorithmic strategies for smooth and non-smooth constrained problems. Applications in stochastic multiobjective, equilibrium, and large-scale mathematical programs. Prerequisite: IE 316 or equivalent.

IE 419. Sequencing and Scheduling (3)
Systematic analysis of models for production planning and scheduling. Topics include facility location and production allocation; resource planning techniques; hierarchical planning; static and dynamic scheduling of activities to production (or project) resources. Prerequisites: IE 251 and IE 316 or equivalent.

IE 421. Nontraditional Manufacturing Processes
Analysis of the processes, sensors, machine tools, and control systems in water jet cutting, electrochemical machining, electric discharge machining, laser and ion beam machining, and ultra high precision machining processes. Prerequisite: Consent of instructor.

IE 422. Measurement and Inspection Systems (3)

IE 424. Robotic Systems and Applications (3)
Detailed analysis for robotic systems in manufacturing and service industries. Topics include task planning and decomposition, motion trajectory analysis, conveyor tracking, error detection and recovery, end effector design, and systems integration. Prerequisite: IE 324 or consent of instructor.

IE 426. Artificial Neural Networks (3)
Neural networks and their function in decision problems in engineering. Pattern recognition and optimization with emphasis on evaluation techniques.

IE 429. Artificial Intelligence Techniques in Combinatorial Optimization (3)
Study of artificial intelligence techniques applied to practical combinatorial optimization problems such as routing, scheduling, partitioning, network design, and VLSI layout/placement. Content of the course includes: NP-completeness, exact and approximation algorithms, heuristic search methods, and probabilistic search methods such as simulated annealing, genetic algorithms and Tabu search. Prerequisite: IE 222, or IE 316 or equivalent.

IE 430. Management Science Project (3)
An analysis of a management problem and design of its solution incorporating management science techniques. An individual written report is required. Recommended to be taken in the last semester of the program.

IE 431. Operations Research Seminar (3)
Extensive study of selected topics in techniques and models of operations research.

IE 433. Manufacturing Engineering Seminar (3)
Extensive study of selected topics in the research and development of manufacturing engineering techniques.

IE 437. Advanced Database Analysis and Design (3)
Intensive treatment of design and application of modern database technology, including information modeling and logical design of databases. Particular emphasis on applications to the manufacturing environment. Prerequisite: IE 310 or equivalent.

IE 438. Advanced Data Communication Systems Analysis and Design (3)
Study of technological development, operational algorithms and performance analysis in data networks. Emphasis on the recent development in communication technologies, modeling and simulation of large-scale networks, routing models and algorithms, and flow control issues. Prerequisite: IE 341 and IE 316, or equivalents.
Techniques used to control manufacturing systems: numerical Taguchi, and others; standards, metrics, costs, benchmarking, quality circles, and continuous improvement; Malcolm Baldridge and other awards, ISO 9000, case studies.

IE 443. Automation and Production Systems (3)
Concepts and principles of automated production lines; analysis of transfer lines; partial automation; mechanized assembly system; flexible manufacturing systems; industrial robots; line balancing; product and process design considerations. Prerequisite: IE 342 or equivalent.

IE 448. Industrial Control Systems for Manufacturing (3)
Techniques used to control manufacturing systems: numerical control, digital control, programmable logic controllers, and sensors. Prerequisite: IE 343 or equivalent or consent of instructor.

IE 449. Advanced Computer-Aided Manufacturing (3)
Numerical control in manufacturing; CAD/CAM systems; computer monitoring and control of manufacturing operations; adaptive control of manufacturing operations. Manufacturing resource planning, computer-aided process planning, and shop floor control. Prerequisite: IE 342 or consent of the department chair.

IE 450. Manufacturing Problems (3)
Discussion and solution of manufacturing problems involving several subfunctions, with emphasis on problem identification and definition; selection of techniques of analysis; procedures for evaluation of proposed solutions.

IE 458. (Eco 358) Game Theory (3)
A mathematical analysis of how people interact in strategic situations. Applications include strategic pricing, negotiations, voting, contracts and economic incentives, and environmental issues. Prerequisites: a calculus course and Eco 105 or 115.

IE 460. Engineering Project (1-3)
An intensive study of an area of industrial engineering with emphasis upon design and application. A written report is required.

IE 461. Readings (1-3)
An intensive study of some area of industrial engineering which is not covered in general courses.

IE 490. Thesis (1-6)
IE 499. Dissertation (1-15)

Interdisciplinary Technology
See listings under Science, Technology and Society.

International Careers

Director. Arthur E. King, Ph.D. (Ohio State), Professor of Economics
Alvin Cohen, Ph.D. (Florida), Emeritus Professor of Economics

This major in the College of Arts and Sciences is designed to meet the needs of students who have chosen an international focus for a career in business, law, foreign service or politics. The curricular objectives are to provide an appreciation and understanding of international organizational environments, global social processes and diverse cultures.

In order to achieve these goals, the international careers major combines elements of traditional liberal arts and business school curricula. Among the traditional liberal arts elements are courses in political science, history, international relations, language and other humanities. With respect to business, there are courses in accounting, finance, and economics. The major also represents an excellent foundation for graduate study leading to an MBA, a law degree, and graduate programs in the social sciences.

Each student completes the courses in a common core and chooses a geographical area in which to complete four courses from offerings in economics, history, international relations, political science and social relations. Three additional functional courses complete the major. Although not required, both language and study abroad experience related to the chosen geographic area will create a strong background for an international career.

Major Requirements

Common Core Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Eco 1</td>
<td>3</td>
</tr>
<tr>
<td>Math 51</td>
<td>3</td>
</tr>
<tr>
<td>either Eco 105 or 115</td>
<td>3 or 4</td>
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<tr>
<td>Intermediate (3) or Applied Microeconomic Analysis (3)</td>
<td>3</td>
</tr>
<tr>
<td>Eco 129</td>
<td>3</td>
</tr>
<tr>
<td>Money, Banking and Financial Markets (4)</td>
<td>4</td>
</tr>
<tr>
<td>Eco 145</td>
<td>3</td>
</tr>
<tr>
<td>Statistical Methods (4) or its equivalent</td>
<td>4</td>
</tr>
<tr>
<td>either Pol 3 or IR 10</td>
<td>3 or 4</td>
</tr>
<tr>
<td>Comparative Politics (4) or Intro to World Politics (4)</td>
<td>4</td>
</tr>
<tr>
<td>either Acct 108 or 151</td>
<td>3 or 4</td>
</tr>
<tr>
<td>Fundamentals of Accounting (3) or Intro to Financial Accounting (3)</td>
<td>3</td>
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</table>

(Note: Acct 151 is recommended if any further accounting study or an MBA is anticipated.)

Geographical Area Courses

Four courses are required from one of these four areas. The total credits must be at least 12 hours.

| Europe                  | 3       |
| Latin America           | 3       |
| Far East/Asia           | 3       |
| Middle East             | 3       |

Appropriate courses may be found in many departments throughout the university, including modern languages and literature. The student with the director's approval will determine a specific set of courses to satisfy this requirement.

Functional Courses

Choose three courses, not less than nine credit hours, from:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Eco 209</td>
<td>3</td>
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<tr>
<td>Comparative Economic Systems (3)</td>
<td>3</td>
</tr>
<tr>
<td>Eco 303</td>
<td>3</td>
</tr>
<tr>
<td>Economic Development (3)</td>
<td>3</td>
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<tr>
<td>Eco 339</td>
<td>3</td>
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<tr>
<td>International Trade (3)</td>
<td>3</td>
</tr>
<tr>
<td>Eco/Fin 340</td>
<td>3</td>
</tr>
<tr>
<td>International Finance (3)</td>
<td>3</td>
</tr>
</tbody>
</table>

Other 200- or 300-level College of Business and Economics courses appropriate for an international focus may be chosen with permission of the director as part of the student's overall major plan.

International Relations

Professor and Chair. Rajan Menon, Ph.D. (Illinois), Monroe J. Rathbone Professor

Professors. Henri I. Barkey, Ph.D. (Pennsylvania), Bernard L. and Bertha F. Cohen Professor; Bruce E. Moon, Ph.D. (Ohio State); Oles...
The Field of International Relations: The reality of an interdependent world is brought home to us every day. Fast-flying, highly accurate nuclear weapons have breached the state's ability to protect its citizens as never before. National economies are so sensitive to the trade and monetary policies and instability of other countries that governments are forced to recognize the limitations of purely national economic policies in a highly interdependent world. Resource depletion, pollution, refugee relief, the indebtedness of developing countries, and nuclear proliferation are truly global problems beyond the ability of any one state, no matter how powerful, to address alone.

The Department of International Relations seeks to provide students with a systematic understanding of world politics. The questions that preoccupy scholars of international relations are too numerous to list here, but students who major in international relations can expect to acquire a detailed knowledge of topics such as: contending theories of world politics; the foreign policies of the major powers; the international relations of major regions; international security and arms control; regional conflicts; global problems such as terrorism, refugee relief, and pollution; the politics of global economic relations; and the role of international organizations such as the United Nations, the International Monetary Fund, and the World Bank. As should be apparent from this list, international relations is a multi-disciplinary field and draws upon concepts and theories from political science, history, economics, anthropology, sociology, philosophy, religion studies, and psychology. Majors are encouraged to take courses in these disciplines.

The Curriculum: To meet educational goals, the Department of International Relations has devised a new curriculum based on four 4-credit courses per semester. The major consists of five segments: 1) a gateway course; 2) a functional core comprising three courses; 3) an area studies focus of two courses; 4) advanced electives (two courses); and 5) a free elective (one course). These curricular innovations will be explained in full when students visit the department to declare a major. Students considering a major in international relations are strongly advised to take Eco 1 (Economics); and Math 12 (Basic Statistics) to fulfill their college distribution requirements.

Students may also minor in international relations by taking the gateway course (IR 10) and three other courses offered by the department.

Beyond the Curriculum: In close cooperation with the international education office, the department assists students interested in study abroad programs. In addition, Lehigh has an array of summer programs, which involve course work and/or internships in such countries as China, the Czech Republic and the United Kingdom.

Every semester speakers with expertise on various aspects of world affairs visit Lehigh. The department arranges the annual Cohen International Relations Lecture Series, which has featured speakers such as Robert McNamara, Valery Giscard d'Estaing, Vaclav Havel, Hans Dietrich Genscher, Kim Campbell, Oscar Arias, Wole Soyinka, Andrei Kozyrev, Anthony Lake, and George Mitchell.

The student-run World Affairs Club sponsors a number of activities each year, including student-faculty socials, guest speakers and related programs. It organizes the Model United Nations program to which Lehigh sends a delegation each year. Another delegation is sent annually to the European Union Simulation in Washington, D.C. From time to time, delegations are also sent to other student conferences, including West Point and the U.S. Naval Academy.

The department also offers an internship program for students interested in working in Lehigh's international education office, and the Office of Community Affairs.

Upon Graduating: While a degree in international relations does not lead to a specific career in the way that, for example, accounting or engineering does, a major in international relations, by emphasizing clarity in speech and writing, analytical skills, and a detailed knowledge of world politics prepares students for careers in government, journalism, law, international business, and teaching and research. Recent IR graduates currently work in all of these fields. Some have gone directly into careers upon graduating; others have enrolled in graduate school prior to employment.

Major in International Relations

The major consists of nine 4-credit courses for a total of 36 credits. The distribution of these courses is as follows:

Gateway course
IR 10 Introduction to World Politics (4)

Functional core (three courses).
IR 56 European International Relations (4)
IR 125 International Political Economy (4)
IR 205 Theories of International Relations (4)

Area studies focus (two courses).
Any two IR area studies courses, not including 300-level courses and U.S.-based courses. The following non-IR courses may also be taken to meet this requirement: AAS 171/Hist 171, AAS 331/Hist 331, POLS 226. These and other non-IR courses that count toward this requirement are on a list that the department updates periodically.

Advanced courses (two courses).
In addition to the above, any two IR courses numbered 210-387 and 393.

Free elective.
Any IR course other than IR 1, 90.

Departmental Honors
To graduate with honors, a major in international relations must (a) attain an average of at least 3.5 in the courses constituting the major program; and (b) complete a two-semester honors thesis in the senior year.

Minor in International Relations

The minor consists of four 4-credit courses, for a total of 16 credits: IR 10, one advanced IR elective numbered 210-387 and 393, and two IR electives other than IR 1, 90.

Undergraduate Courses
IR 1. Current Issues in World Affairs (3)
This is a survey course designed primarily for non-IR majors or minors. The purpose is to acquaint students with some of the concepts and historical facts behind current global issues. The content of this course will, in part, be dictated by international events as they unfold. Barney. (SS)

IR 10. Introduction to World Politics (4)
Introduction to the major principles, concepts, and theories of international relations, along with a historical background focusing on the 19th and 20th centuries. Topics to be covered include the nature of power, balance of power theories, national interest, decision-making in foreign policy, theories of war and expansion, patterns of cooperation, and international political economy. Menon. (SS)
IR 23. Alternative World Futures (4)
After a survey of the major political, military, economic, and social trends of the 20th century, the course will examine the challenges that are likely to confront the world in the 21st century. Topics to be explored include environmental and population problems, the changing nature of war, ethnic conflict and nationalism, and the emerging balance of global economic and military power. Menon. (SS)

IR 34. Society, Technology and War (4)
The role of war in the modern world; the impact of social, economic, and technological change on the function and conduct of war; World Wars I and II; Vietnam; the nuclear revolution; possible future developments. Kaufmann. (SS)

IR 56. European International Relations (4)
Survey of European international relations since the French Revolution with an emphasis on the rise and decline of the major powers. Among the topics discussed will be nationalism, imperialism, the causes of war, and attempted peace settlements. After 1945, the focus will be on the effects of the Cold War, the emergence of the European Union, and the impact of the collapse of the USSR on the political and strategic structure of Europe. Smolansky. (SS)

IR 61. (ASIA 61) East Asian International Relations (4)
Introduction to East Asian international relations with emphasis on post-1945 period: historical background, Cold War conflicts, China’s rise to power, Japan’s growing role Korea and the NICs in Southeast Asia, U.S. and Russian policies, current and future issues. Wylie. (SS)

IR 72. The United States in the Global Economy (4)

IR 74. United States Foreign Policy (4)
Major themes and trends in U.S. foreign policy, with attention to both the historical evolution of contemporary policy and key current problems. Emphasis is on critical examination of the interests and values that underlie the goals of policy and the theories that shape perceptions of how they can be met. Sources of U.S. policy, including decision-making structures, policy processes, and the role of the public and media. Kaufmann, Moon. (SS)

IR 75. Canada-United States Relations (2)
Introduction to Canada’s relations with the United States, with emphasis on the post-1945 period. Coverage of political, economic and security issues in the bilateral relationship and the broader international scene. A half-semester course. Wylie. (SS)

IR 81. Middle East in World Affairs to 1945 (4)
Political, economic, and social forces behind the rise of modern states in the Middle East; area’s role in international politics from Napoleon’s invasion of Egypt to the end of World War II. Smolansky. (SS)

IR 82. Middle East in World Affairs Since 1945 (4)
Rise of Turkish, Iranian, and Arab nationalism; creation of Israel; decline of British and French power; growth of U.S. and Soviet influence; Middle East as the world’s major oil producer. Smolansky. (SS)

IR 119. Issues in International Relations (1-4)
Readings on selected themes in world politics, with theme to change each semester. Offered on an occasional basis only. Staff. (SS)

IR 125. International Political Economy (4)
Principles governing the interaction between the economic and political components of international phenomena. Political causes and consequences of trade and investment. Foreign economic policy and its relationship to domestic economic policy and other aspects of foreign policy. Determinants of foreign economic policy. Prerequisites: Economics 1, 11 or 12; and IR 10. Moon. (SS)

IR 127. Research in International Relations (4)
Research skills in international relations. The role of theory, models and evidence in the explanation of international phenomena. Literature review; problem formulation; theory construction; research design, methods and measures; collection, analysis and interpretation of data; principles of hypothesis testing. Professional writing, either through individual research projects under faculty supervision or an apprenticeship in ongoing faculty research projects. Prerequisite: Consent of the instructor. Moon (SS)

IR 132. Nationalism and Ethnic Conflict (4)
The nationalist ideal and sources of national identity. The political uses of nationalism and how identities are manipulated. Sources of ethnic conflict, war, and genocide. Proposals for managing ethnic conflict. India, Bosnia, Rwanda and other current cases; future prospects. Kaufmann (SS)

IR 161. (ASIA 161) China in World Affairs (4)
China in world affairs, emphasizing role in Pacific Rim: historical background; domestic politics; foreign and security policies; relations with regional and global powers; policies toward Third World; current and future issues. Wylie. (SS)

IR 163. (ASIA 163) Japan in World Affairs (4)
Japan in world affairs, emphasizing role in Pacific Rim: historical background; domestic politics; foreign and security policies; relations with major powers; policies toward Third World; current and future issues. Wylie. (SS)

IR 164. (ASIA 164, Rel 164) Japan’s Response to the West (4)
A survey of Japanese history and culture from 1500 to the present, following the theme of Japan’s contact with the West. What enabled Japan to modernize and Westernize so successfully? Topics covered include: the expulsion of Christianity, the first samurai mission to the U.S., the postwar American occupation, and contemporary issues. Readings include Japanese novels and short stories (in translation). Kraft. (SS)

IR 167. Diplomacy of Russia to 1917 (4)
Expansion of the Russian Empire; principles of Russian foreign policy and their specific applications under the Tsarist governments, treated partially as background of Soviet policy; interaction between Russian domestic and foreign affairs. Smolansky. (SS)

Topical and chronological survey of Soviet foreign relations; Soviet efforts to survive in a hostile capitalist environment; consolidation of gains made during World War II; origins of Cold War; friction within the Communist Bloc (Eastern Europe, China); nuclear arms race; striving for detente; activity in the Third World; Gorbachev and collapse. Smolansky. (SS)

IR 169. International Relations of Russia and Eastern Europe (4)
The Soviet collapse and the emergence of Russia. Russia’s relations with the other newly-independent states that emerged following the disintegration of the Soviet union. The international relations of Eastern Europe (including the Balkans). Menon. (SS)

IR 177. International Relations of Latin America (4)
Survey of major international and domestic crises facing Central and South America. Examines factors affecting Latin American system of states such as international debt, involvement of foreign powers, and social and political instabilities. Barkey. (SS)
IR 205. Theories of International Relations (4)
Analysis of the role of theory in historical explanation, prediction, and policy design. Examination of important theoretical approaches to international relations, including role of states' external environment; balance of power; international institutions; economic and political structures of states; nationalism; role of bureaucracies and individual leaders; impact of beliefs and images, psychological explanations. Prerequisites: IR 10 and 56. Kaufmann. (SS)

IR 246. (Jour 246) International Communication (4)
Role of international news media in world affairs. Global theories of the press; process and influence of U.S. reporting of international affairs; survey of global media systems; global communication controversies. Lu (SS)

IR 302. Rise and Decline of Empires (4)
An overview of the expansion, over-extension, and collapse of empires. Focus on alternative theories of empires as well as historical cases. Prerequisites: IR 10 and 56. Menon. (SS)

IR 321. Economic Relations of Advanced Industrial Societies (4)
Foreign economic policies of advanced industrial nations. Bilateral and multilateral economic relations; international economic regimes and institutions; interdependence and cooperation; managing conflict. Prerequisite: IR 125. Moon. (SS)

IR 322. Political Economy of North-South Relations (4)
Political economy of relations between developed and less developed countries. Explanations for choices of development policy, especially issues of trade, foreign aid, and foreign direct investment. Consequences of North-South transactions. Controversies over system structure and international institutions. Prerequisite: IR 125. Moon. (SS)

IR 323. Political Economy of Newly Industrializing Countries (4)
Issues of development, debt and adjustment in newly industrializing countries. Analysis of the differences between the development strategies adopted in Latin America and East Asia. Explanations for patterns of success and failure. Origins of underdevelopment; the politics of failed development strategies; the challenge of the increasingly competitive world economy and relations with the U.S. and other developed nations. Prerequisite: IR 125. Barkey. (SS)

IR 332. Role of Force in International Relations (4)
Theories of war and international insecurity; arms races; influence of domestic politics and bureaucracies; misperception. The use of war in the context of organization, deterrence; alliances; collective security; arms control. Nationalism; the nuclear and information revolutions; the changing usefulness of force. Prerequisites: IR 10 and 56. Kaufmann. (SS)

IR 344. International Politics of Oil (4)
Historical influence of oil in international politics and the role it plays today. Focus on differing views of producers, such as Middle Eastern and Latin American states, and consuming nations, largely the economically developed Western states. Barkey. (SS)

IR 354. International Relations of the Middle East (4)
Importance of the Middle East in contemporary world politics; strategic location and natural resources as factors affecting interests of the great powers. Interplay of international, regional, and internal forces. Prerequisite: IR 80 or 82. Smolansky. (SS)

IR 364. International Relations of East Asia/Pacific Rim (4)
Research-oriented seminar on contemporary international relations of East Asia/Pacific Rim. Special emphasis on China, Japan and regional organizations. Substantial research paper on topic of student's own choice is required. Prerequisite: IR 61, 163 or 164. Wylie. (SS)

IR 367. Seminar in the International Relations of Russia and Eastern Europe (3)
Analysis of the international causes and consequences of the Soviet Union's collapse, the foreign relations of Russia and the other states of the former USSR. Prerequisites: IR 168 or IR 169. Menon, Smolansky

IR 388. Honors Thesis in International Relations (4)
Honors thesis in international relations for majors with senior standing and with a 3.5 GPA who wish to engage in an intensive, two-semester research project under the direct guidance of a faculty member in the student's special area of interest. Departmental permission required. May be repeated for credit. Staff. (SS)

IR 390. Readings in International Relations (1-4)
Directed course of readings intended for students with special competence or interest in fields of international relations not fully covered by regular course offerings. May be repeated for credit. Departmental permission required. Staff. (SS)

IR 393. Seminar in International Relations (4)
Advanced seminar focusing on discussion and research on specialized subjects in international relations. Variable subject matter. Offered by faculty on rotating basis. May be repeated for credit. Senior standing and departmental permission required. Staff. (SS)

IR 394. Special Topics in International Relations (1-4)
Intensive, research-oriented study for students with a special competence or interest in fields of international relations not fully covered by regular course offerings. May be repeated for credit. Departmental permission required. Staff. (SS)

IR 395. Internship in International Relations (1-4)
Internship in public or private agency. May be repeated for credit. Departmental permission required. Staff. (SS)

Japanese
See Listings under Modern Languages and Literature.

Jewish Studies
The Jewish studies minor offers students the opportunity to explore the history, literature, religion, and social institutions of the Jewish people from its inception to the present. The diversity of courses highlights the interaction of Judaism with other world civilizations and the mutual influences between Judaism and societies and cultures of Europe, the Middle East, and the United States. Through the Jewish studies minor, a student has the opportunity to study Judaism from the perspective of various academic disciplines.

The program is designed to be of interest to students with diverse interests and fields of concentration. The study of Jewish society and culture can enhance one's understanding of European or American society and culture. Students of psychology and sociology will find that Jewish studies contributes to their understanding of such issues as prejudice and anti-Semitism, assimilation, and religious-cultural pluralism.

The study of Jewish religion and philosophy brings one face-to-face with such problems as God, religious faith and doubt, moral responsibility, evil, and human suffering. In addition, studying Judaism in comparison with another religious tradition heightens one's understanding of both religions. The study of Judaism introduces the student of literature to a broad sample of diverse literary forms and themes from diverse periods and cultural settings.
The formal program of courses is augmented through a program of lectures, colloquia, films, and other cultural events. Study abroad, particularly in Israel, is encouraged to augment and broaden students’ understanding of Jewish civilization. Under the sponsorship of the Philip and Muriel Berman Center for Jewish Studies, students may study for a semester or a year at the Hebrew University in Jerusalem or Tel Aviv University. During the summer, students may earn up to six credit hours by participating in the Tel Aviv University summer program or the Hebrew University summer study program in Jerusalem. For further information on programs in Israel and scholarships available, students should contact Shirley Ratushny of the Berman Center. Students should coordinate their minor program in Jewish studies with the director of the center, Laurence J. Silberstein, Maginnes Hall.

A minimum of 16 credit hours is to be selected from the following courses. (A maximum of eight credit hours of Hebrew may be counted.) In addition to the following courses, which are offered regularly, new courses are offered annually. Students should check with the Jewish studies office, Maginnes 324, for an updated list.

Hebr 1 Elementary Modern Hebrew I (4)
Hebr 2 Elementary Modern Hebrew II (4)
Hebr 11 Intermediate Modern Hebrew I (4)
Hebr 12 Intermediate Modern Hebrew II (4)
IR 81 Middle East in World Affairs to 1945 (4)
IR 82 Middle East in World Affairs Since 1945 (4)
Phil/Rel 129 Jewish Philosophy (4)
Phil 133 Medieval Philosophy (4)
Rel 73 The Jewish Tradition (4)
Rel 111 Jewish Scriptures / Old Testament (4)
Rel 112 Jewish Origins: The Beginnings of Judaism and Jewish Diversity in the Greco-Roman World (4)
Rel 121 Sources for the Life of Jesus: Jewish and Christian Context (4)
Rel 132 Hasidic Tales (4)
Rel/WS 138 Women in Jewish History (4)
Rel 139 Jewish Folklore (4)
Rel 150 Judaism in the Modern World (4)
Rel 152 American Judaism (4)
Rel/Hist 154 The Holocaust: History and Meaning (4)
Rel 155 Jewish Responses to the Holocaust (4)
Rel 156 Israel, Zionism, and the Renewal of Judaism (4)
Rel/WS 158 Sex and Gender in Judaism: The Feminist Critique (4)
Rel 174 Contemporary Theology (4)
Rel 186 Judaism in Israel and the United States (4)
Rel 230 The Mystical Tradition: Judaism (4)
Rel 371 Directed Readings (1-4)
US 85 American Jews: Politics and Culture (3)

Journalism and Communication

Professor. Sharon M. Friedman, M.A. (Penn State), Iacocca Professor and director of science writing program; Carole M. Gorney, M.S.J. (Northwestern), APR, Fellow (PRSA) director of public relations concentration.

Associate professors. Jack Lule, Ph.D. (Georgia) chair; Walter W. Trimble, M.A. (Ohio State).


Adjunct professors: Kenneth Friedman, Ph.D. (Penn State); Glenn Kranzley, B.A. (Penn State); Robert Rosenwein, Ph.D. (Michigan); William White, M.A. (Ohio State); Dina Wills, Ph.D. (Oregon), director of communication minor.

The Department of Journalism and Communication offers major and minor programs in journalism (news and public relations concentrations) and science writing, and an interdisciplinary communication minor.

Journalism is crucial to the public life of a democracy. At its best, journalism serves as a watchdog to government, offers a voice for the powerless at home and abroad, entertains and instructs the public, represents the views of varied constituencies, monitors and protects the environment and public resources, and provides a common memory for a people.

The purpose of the journalism program is to provide students with the knowledge and skills to fulfill such roles. The program emphasizes research, writing, editing, and critical thinking and analysis. Students integrate online technology with legal and ethical thinking and a global perspective that will prepare them for numerous opportunities in and out of journalism.

In the news concentration, students take courses in news and feature writing, editing and design, law and ethics, advanced research and reporting, a seminar in online journalism, and a professional internship. The department has a national reputation in online journalism. All courses have online research and writing components. Experimental coursework, such as in cyberdesign and multimedia writing, is offered regularly.

In the public relations concentration, students take a core set of journalism courses, including editing and design, law and ethics, feature writing and a professional internship. They also take courses in public relations theory, writing, case studies, and persuasion and public relations and a practicum. In addition, students take choice courses in specialties such as public affairs, hospital, health care and corporate communication.

A second major program available to students is the science writing major. Students learn to write about pure and applied scientific research, technology, engineering, the environment and medicine and health for a variety of audiences ranging from the general public to scientists and engineers in industry and government. Students can also gain experience in the science writing field research program. A minor in science writing is available that may be valuable for students with majors in science or engineering.

An interdisciplinary minor in communication is offered for students interested in developing oral communication skills and a better understanding of how people share meaning through persuasive use of rhetoric, logic and symbols in public, one-to-one and small group communication.

Career opportunities are numerous for graduates of the department.

Students in the news concentration find work with newspapers, wire services, magazines, cable, television and radio stations, web sites, public relations and other media outlets. Others have used their background in journalism as a basis for the study and practice of law, graduate study in a variety of disciplines, government service, teaching and business management.

Students in the public relations concentration will be prepared for both entry-level positions and later management responsibilities in government, corporations, hospitals, health care organizations, universities, sports information, nonprofit agencies and other groups.

Students in science writing can expect to pursue careers in science journalism; public relations for scientific societies, government agencies, universities or hospitals; technical writing for industry and government agencies, and other areas, such as management, administration and teaching. The program also prepares students for graduate study in science writing, journalism and other disciplines.

The interdisciplinary minor in communication will be useful to students interested in organizational and written communication, law, business, philosophy, government, marketing, teaching, telecommunication or other careers where successful communication is important.
Students choose two elective courses from specialty areas below.

- Hospital/Health Care
- Science/Environment
- Sports Information

Elective courses for public relations concentration will be chosen from the following specialty areas:

Public Affairs (Political Science)
Corporate Public Relations

**Note:** A minimum of two semesters of one-credit public relations practicum are required. The practicum projects provide students with experience in public relations activities and campaigns conducted on campus, or in regional and national student competitions. Projects will be assigned by the instructor, in consultation with the student.

18 credit hours are required.
Communication Minor

Purpose: This minor guides students to a better understanding of how people share meaning through persuasive use of rhetoric, logic and symbols in public, small group, dyadic, organizational and visual communication. It will be relevant to students interested in law, organizational communication, philosophy, government, marketing, teaching, or any occupation where it is essential to communicate information to others successfully.

The perspectives taken by the minor are those of rhetorical theory and communication theory. The student will become acquainted with major theories, concepts and issues concerning the available means of persuasion, and with the techniques used to communicate successfully with others. Experiential learning includes the construction and delivery of oral presentations, writing, graphics and participation in small group and teamwork situations.

This interdisciplinary minor is administered by the Department of Journalism and Communication. It is advised by an interdisciplinary committee of faculty members with both teaching and research interests in these areas. Students are encouraged to become involved with communication research activities under the guidance of interested faculty members.

Courses. The minor represents 17-18 credit hours. It consists of one required course in communication theory (Comm 143 or SSP 135) and one required course in public speaking (Comm 130). An additional 10-11 credits may be chosen from two of the four groups below. One of these courses must be at or above the 200-level. With the consent of participating instructor and the director of the minor, a student may elect to take a Special Topics (Comm 325) project as part of the 10-11 elective credit hours. Another possible elective is a 4-credit internship in journalism and communication or in art and architecture, provided that the student meets all departmental requirements for such an internship.

The director is Dina Wills, Department of Journalism and Communication, University Center.

Required courses (6-7 credits)
Comm 130 Public Speaking (3) and either
Comm 143 Persuasion and Influence (4) or
SSP 135 Human Communication (3)

Elective courses (10-11 credits) chosen from at least two of these groups. One course must be at or above the 200-level.

Group I: Public Communication
Comm 143 Business and Professional Speaking (3)
Comm 144 Effective Interviewing (3)
Poli 329 Propaganda and American Politics (4)
Jour 127 Public Relations Principles (4)
Jour 229 Public Relations Case Studies (4)
Jour 246 (IR 246) International Communication (4)
Jour 306 Applied Public Relations (4)
Mgt 307 Business Communication Skills (3)
Mkt 313 Marketing Communications (3)
Mkt 316 Advertising (3)

Group II: Communication in Writing
Engl 171 Writing for Audiences (4)
Engl 347 The Essay (4)
Jour 123 Basic Science and Technical Writing (4)
Jour 128 Writing for Public Relations (4)
Jour 240 Writing for Broadcasting (4)

Group III: Interpersonal, Group and Organizational Communication
A&S 250 Interpersonal Development in a Changing Society (3)
Comm 65 Interpersonal Communication in a Changing World (3)
Comm 143 Persuasion and Influence (4)
Mgt 270 Organization Theory and Behavior (3)
Mgt 321 Organizational Behavior Workshop (3)
SSP 125 Small Groups (3)
SSP 135 Human Communication (3)
SSP 312 Communication in Groups (3)

Group IV: Visual Communication
Art 53 Introduction to Graphic Communication (3)
Art 77 Photography I (3)
Art 177 Photography II (3)
Art 153 Graphic Communication II (3)
Art 253 Graphic Communication III (3)
Jour 141 Photographic Journalism (3)

Other Options
Comm 325 Special Topics in Communication (1-4)
Jour 361 Internship (1-4) department permission required
Art 375 Internship (1-4) department permission required

Computer Laboratories
Journalism students use three networked computer laboratories for classes and outside assignments. One is a newspaper production lab with a mixture of word-processing terminals and Macintosh computers. Another is a classroom of Windows computers with access to the Internet. The third is made up of Macintosh computers used in pagination and desktop publishing instruction. Computers are used extensively for research, communication, writing, editing, and layout and design.

Journalism Courses
NOTE: Some journalism and communication courses require departmental permission before students can register for the class. Check the course schedule each semester.

Media Internships
All majors in journalism and journalism/science writing take professional internships that provide real-world experience with area newspapers, magazines, cable, television or radio stations, web sites or in public relations or advertising settings. Science writing minors may take an internship instead of working on The Brown and White.

Jour 1. Brown and White (1) every semester
Enrollment constitutes membership on the staff of the semi-weekly undergraduate newspaper. Newspaper staff members are selected based on their interests and skills. Students who preregister for this course are told at the beginning of the semester whether they have been selected for the staff. First- and second-semester freshmen are given priority. Prerequisite: Freshman or sophomore standing; juniors only with consent of department chair. Lule/Trimble. (ND)

Jour 2-10. Brown and White (1-2) every semester
Enrollment constitutes membership on the staff of the semi-weekly undergraduate newspaper. Newspaper staff members are selected based on their interests and skills. Students who preregister for this course are told at the beginning of the semester whether they have been selected for the staff. Prerequisite: Jour 11 or Jour 123 or consent of the department chair. Lule/Trimble. (ND)
Study of and practice in writing about scientific and technical subjects for audiences ranging from the general public to scientists and engineers. Starts with basic science writing for lay audiences, emphasizing organization and clear writing techniques. As the course progresses, material becomes more technical, concentrating on how to write effective technical reports, descriptions, papers and memoranda. Also explores problems of conveying highly complex technical information to multiple audiences, factors that influence science communication to the public, and interactions between scientists and journalists. K. Friedman. (SS)

Jour 124. (STS 124) Politics of Science (3) fall
Analysis of the multi-dimensional interaction between the federal government and the scientific community. Explores historical growth of the science-government connection, the scientific establishment both past and present, and the role of scientific advice to the White House and Congress. Also examines ethical issues, public attitudes toward science, science-society interactions and case studies of scientific controversies. S. Friedman (SS)

Jour 125. Environment, the Public and the Mass Media (4)
every semester
Extensive exploration of local, national and international environmental problems and their social, political, and economic impacts. Analysis of mass media coverage of complex environmental issues and the media's effects on public opinion and government environmental policies. Examination of environmental journalism principles and practices in the United States and around the world. S. Friedman (SS)

Jour 127. Public Relations Principles (4) fall
Emphasis on management function of public relations, including research, planning, counseling, programming, communication and maintenance. Study of communication and persuasion theory, public opinion and ethics. Student teams work outside class for a community client, helping research and implement an actual public relations program during the semester. Gorney. (SS)

Jour 128. Public Relations Writing (4) spring
Basics of news writing (structure and style) applied to the preparation of informational, promotional and persuasive messages; principles of effective media relations, and methods to generate positive publicity; preparation of media kits (backgrounders, fact sheets, story tip sheets). Student teams work outside class to develop a publicity plan and supporting publicity materials for an on-campus student organization-sponsored event. Prerequisite: Jour 127. Gorney. (ND)

Jour 129. Specialized Writing in Public Relations (3) fall
Preparation and writing of promotional and publicity materials, including public service announcements, radio and television; preparation of audio-visual materials and presentations; planning and conducting news conferences; media interview techniques in negative situations; writing informational and persuasive speeches for others. Students will produce finished public service announcements and be videotaped giving actual media interviews. Prerequisite: Jour 11, 123, 128 or consent of department chair. Gorney. (ND)

Jour 134. (SPS 134) Human Communication (3)
Processes and functions of human communication in relationships and groups. Rosenwein. (SS)

Jour 141. Photojournalism (4) summer
Ethics and history of photojournalism; instruction and practice in basic camera techniques; scanning and digital manipulation of black and white and color photographs using Adobe Photoshop; cropping and sizing photographs and production of layouts using QuarkExpress. Trimble (ND)

Jour 212. Feature Writing (4) every semester
Conceiving and developing feature stories for newspapers and magazines; interviewing techniques; writing non-fiction using the techniques of the novelist; marketing freelance projects. Prerequisite: Jour 11, 123 or 128. Trimble. (ND)

Jour 214. Reporting of Public Affairs (4)
Reporting and writing news of government on the local, county, state and federal levels; civil and criminal courts; labor, environment, housing and community planning news. Prerequisites: Jour 11 or 123 and PolS 177. Trimble. (ND)
Jour 215. Publication Design (3)
Advanced study of publication design: newspapers, magazines, pamphlets, annual reports; symbols, typography, grids, use of photographs and infographics; use of Macintosh computer in page production, and in creating and manipulating art for publication. Prerequisite: Jour 13 or permission of the department chair. Trimble (ND)

Jour 220. Reporting on Business and Economics (3)
The principles behind the economy, the markets and companies and how to report on them; the role of business reporting in the media; the use of computer technology in business reporting. Prerequisite: Jour 11 or Jour 123 and Eco 1. (SS)

Jour 229. Public Relations Case Studies (4) fall
Analysis of public relations programs and practices in business and industry, government, and non-profit organizations. Study focuses on principles that govern employee, community, consumer and media relations, as well as issues management and special events and promotions. Students select, research and write a fully documented major case study using both primary and secondary sources, as well as preparing audio/visual aids to support an oral presentation to the class at the end of the semester. Prerequisite: Jour 127. Gorney. (ND)

Jour 231. Science Writing Practicum (1-4) spring
On-site experience as an editor at a major scientific meeting, or writing for scientific organizations. Course may be repeated for a maximum of eight credits. Prerequisites: Jour 11 or Jour 123 or Jour 311, junior standing, and consent of the department chair. Friedman. (ND)

Jour 232. Journalism Practicum (1-4) every semester
Practical application of journalism principles and skills in semester-long projects, as well as various on- and off-campus work experiences. Course is designed to provide credit for supervised experience, particularly through study abroad programs, that does not meet the more rigorous, required internship. May be repeated for maximum of eight credits. Prerequisites: consent of department chair. Staff. (ND)

Jour 233. Public Relations Practicum (1-4) every semester
Practical application of public relations principles to various semester-long projects, or to competitive programs sponsored by professional and academic public relations societies. The amount of credit is negotiable with the instructor based on the amount of work done and the complexity of the projects undertaken. Prerequisites: Jour 127 and 128 (with permission, Jour 128 may be taken concurrently with practicum) (Jour 229 required for the Bateman Case Study competition). Gorney. (ND)

Jour 240. Writing for Broadcasting (4) spring
Basic writing style for radio and television news, and scripting newscasts in a variety of formats, including electronic news gathering and voice overs. Scripting and storyboarding for commercials and public service announcements. A three-hour writing lab is included. A portion of the course is devoted to study and discussion of issues related to television news coverage. Gorney. (ND)

Jour 246. (IR 246) International Communication (4)
Role of international news media in world affairs. Global theories of the press; process and influence of U.S. reporting of international affairs; survey of global media systems; global communication controversies. Lule. (SS)

Jour 306. Applied Public Relations (4) spring
Study and application of crisis planning, management and communication principles to problems faced by a variety of profit and non-profit organizations. Study includes use of Macintosh computer in page production, and in creating and manipulating art for publication. Prerequisite: Senior standing and declaration of major in journalism, science writing, public relations or communication and consent of the department chair. Friedman (ND)
Jour 365. Advanced Research and Reporting (4) fall
Planning, researching and writing comprehensive news projects; special attention paid to computer-assisted research, online resources, investigative techniques, interviewing skills, reporting on local, county, state and federal governments and courts; emphasis also given to organizing and writing in-depth articles. Prerequisites: eight hours in journalism and senior standing or permission of department chair. Lule, Trimble (ND)

Jour 366. Online Journalism (4) spring
The course examines the social, cultural, political, legal and economic influence of online technology on journalism and the role of journalism in society. Emphasizing critical thinking and analysis, the course studies the ways in which digital technology has changed the way journalists research, write, edit and design. Lule (ND)

Jour 389. College Scholar Project (1-8)
Opportunity for college scholars to pursue an extended project. May be repeated for credit. College-wide course designation. Transcript will identify department in which project was completed. Prerequisite: consent of department chair. Staff. (ND)

Jour 390. Honors Thesis (1-4)
Directed undergraduate research thesis required of students who apply for and qualify for graduation with departmental honors. Staff. (ND)

Jour 391. Special Topics in Journalism (1-4)
Directed research or writing involving a subject or issue in journalism not covered in other courses. May be repeated for credit. Prerequisite: 12 hours in journalism or consent of the department chair. Staff. (ND)

Communication Courses
Comm 60. Fundamentals of Speech Communication (3)
The basic principles of communication: the informative speech, small group communication process, principles of persuasion, effects of mass communication. Two speeches, group project. Wills. (ND)

Comm 65. Interpersonal Communication in a Changing World (3) every semester
This course helps develop a better understanding of how we communicate with others, verbally and non-verbally, individually and in groups; and how communication affects how we develop our own concept of who we are. The course examines critical thinking and how it relates to the communication process. The concepts of stigma and prejudice are examined in the context of interpersonal communications. (ND)

Comm 130. Public Speaking (3) every semester
Applying the principles of public speaking to make informative and persuasive presentations effectively. Emphasis on speech composition and effective oral communication skills. Ross. (HU)

Comm 143. Persuasion and Influence (4) fall
The social, symbolic, and rhetorical means of persuasion and how this persuasive influence is expressed in politics, advertising, and the mass media. Course includes two group projects, a term paper, 3-4 brief synthesis papers and a take-home final. Wills (SS)

Comm 144. Effective Interviewing (3) spring
Theory of effective interviewing; how to plan and structure an interview outline; types of questions used in interviews; how to open, conduct and conclude an interview. Special emphasis on the journalistic, employment and broadcasting interview. Instructor will use role-playing and videotaping. Students will prepare and conduct simulated interviews. Wills. (ND)

Comm 325. Special Topics in Communication (1-4)
Research and writing or performance involving a topic, medium or issue in journalism, public relations, speech or communication theory not covered in other courses. Prerequisite: nine hours in journalism, public relations or communication and consent of department chair. (SS)

Comm 331. Business and Professional Speaking (3) fall
The principles of oral communication as applied to business and professional situations. Professional presentations, small group interaction and interpersonal communication in the business setting. Prerequisite: junior or senior standing. Ross. (ND)

Languages
Courses are listed alphabetically under Modern Languages and Literature and Classical Studies.

Latin American Studies
The minor in Latin American studies represents an opportunity to explore the language, literature, history, cultures, and socioeconomic problems of our neighbors to the south. It provides a perspective on the problems of other underdeveloped regions of the world, in contrast to most offerings in the humanities and social sciences that usually focus on the mainstream of western culture, notably the United States and Western Europe.

It is worth noting the importance of Latin American cultures in the future of the hemisphere. Latin America is the most rapidly growing part of the world, and by the year 2000 it is predicted that the area will have a population of 600 million, or twice that of Anglo-America. Several countries, especially Brazil and Mexico, are undergoing rapid industrial expansion. Consequently, besides the personal values to be derived from this curriculum, there are business, governmental, and related career possibilities.

The minor program requires 15 to 16 credit hours, chosen from economics, history, political science, Spanish, anthropology, and IR in discussion with the coordinator, Antonio Prieto, Modern Languages and Literature, Maginnes Hall.

Requirements (8 credits).
A. History/Culture (4 credits). Choose one of the following:
Hist 49 History of Latin America (4)
Hist 50 History of Latin America (4)
Span 152 The Cultural Evolution of Latin America (taught in Spanish) (4)

B. Language (4 credits). Choose one of the following:
Span 2 Elementary Spanish II (4)
Span 12 Intermediate Spanish II (4)

Elective courses (7-8 credits) chosen from the following courses.
No more than two courses may be taken in any one department:
Anth 178 Mesoamerican Archeology (3)
MLL 51 Contemporary Hispanic-American Literature (4)
MLL 53 The Hispanic World and Its Culture (4)
Eco 305 The Economic Development of Latin America (4)
Hist 49-50 History of Latin America (4)
Hist 265 Mexico and the Caribbean (4)
Hist 266 Argentina, Brazil and Chile (4)
Hist 368 Seminar in Latin American History (4)
IR 177 International Relations in Latin America (4)
PolS 222 Politics of Developing Nations (4)
PolS 235 Latin American Political Systems (4)
PolS 236 U.S. Foreign Policy and Latin America (4)
The Department of Finance and Law offers the following courses numbered 200 and above in the College of Business and Economics.

**Law**

**Professor.** Perry A. Zirkel, J.D., LL.M. (Yale), Ph.D. (Connecticut), University Professor of Economics and Law.

**Associate professors.** George A. Nation III, J.D. (Villanova); Matthew A. Melone, J.D. (Pennsylvania), C.P.A.

**Adjunct professors.** Nancy T. Schneiderman, J.D. (Harvard); Charles Shoemaker, Jr., J.D. (Yale); Patrick F. McCormick, J.D. (Ohio Northern); Jeffrey M. Miller, J.D. (John Marshall).

The Department of Finance and Law offers the following undergraduate courses:

**Undergraduate Courses**

**Law 101. Introduction to Law (3)**
A study of the nature and function of law and the legal system, the study of legal reasoning through the use of the case method.

**Law 111. Criminal Trials and Procedures (1)**
The course focuses on criminal law and procedure from actual indictment and/or arrest through and including the appellate procedure. Tactics and strategy within the framework of the various steps of a typical criminal proceeding are discussed. Guest speakers contribute to the course which in the past included Philadelphia police inspectors talking about investigations and polygraphs; an FBI Agent on arrests and indictment and/or arrest through and including the appellate procedure; tactics and strategy within the framework of the various steps of a typical criminal proceeding are discussed. Guest speakers contribute to the course which in the past included Philadelphia police inspectors talking about investigations and polygraphs; an FBI Agent on arrests and indictments.

**Courses numbered 200 and above in the College of Business and Economics are open to sophomores only on petition.**

**Law 201. Legal Environment of Business (3)** every semester
The study of the legal relationships of business and government, business and society and the individual and society. The case method is used to develop analytical skills. Introduction to contract law and the law of sales underlying the free market system. Prerequisite: Eco 1

**Law 202. Business Law (3)** every semester
The law of agency, business organizations, secured transactions, bankruptcy and negotiable instruments. Prerequisite: Law 201.

**Law 221. Sex-Discrimination and the Law (3)**
A critical study of the law of sex discrimination in areas of constitutional and labor law. A case approach that places emphasis on the rights of employees and the obligations of employers. Topics include equal protection, equal employment opportunity, and affirmative action. (HU)

**Law 371. Directed Readings (1-3)**
Readings in various fields of law, designed for students who have a special interest in a field of law.

**Law 372. Special Topics (3)**
Special problems and issues in commercial law.
Course descriptions for the College of Business and Economics graduate courses can be found in this section (Section V) under the heading of Business and Economics Graduate Courses.

**Management**

**Professors.** Richard W. Barsness, Ph.D. (Minnesota); Alden S. Bean, Ph.D. (Northwestern), Kenan Professor of Management and Technology; John W. Bonge, Ph.D. (Northwestern); Michael G. Kolchin, D.B.A. (Indiana) Director, Graduate and Professional Education; Benjamin Litt, Ph.D. (N.Y.U.); John E. Stevens, Ph.D. (Cincinnati) chair, department of management and marketing.

**Associate professors.** Peter P. Poole, Ph.D. (Penn State); Theodore W. Schlie, Ph.D. (Northwestern); Susan A. Sherer, Ph.D. (Pennsylvania); Robert J. Trent, Ph.D. (Michigan State).

**Adjunct professors.** Dennis D. Newhart, MBA (Lehigh); James R. Seifert, M.S.E.E. (Lehigh).

**Visiting professors.** Michael D. Santoro, Ph.D. (Rutgers).

**Management Program and Courses**
The Department of Management and Marketing offers an undergraduate management major. Majors will select either the Specialization (15 hours) or Interfunctional (18 hours) track shown below:

**Specialization (15 hours)**
At least two of the following:
- Mgt 302 Quantitative Models-Conceptual (3)
- Mgt 309 Industrial Purchasing and Materials Management (3)
- Mgt 311 LUMAC Management Assistance Counseling (3)
- Mgt 321 Organizational Behavior Workshop (3)
- Mgt 333 Personnel Management (3)

Plus up to three of the following:
- Eco 234 Labor-Management Relations (3)
- Eco 235 Labor Economics (3)
- Acct 324 Cost Accounting (3)
- Eco 333 Managerial Economics (3)
- Eco 352 Advanced Statistical Methods (3)
- Eco 357 Econometrics (3)
- Fin 328 Corporate Financial Policy (3)
- Mkt 319 New Product Planning (3)
- Mkt 321 Business to Business Marketing (3)
- IE 309 Introduction to Information Systems (3)
- IE 332 Product Quality (3)
- IE 334 Organizational Planning and Control (3)

Courses will be selected in consultation with the faculty advisor to comprise one of the following specialization options: entrepreneurship, human resources management, materials management, and operations management.

**Interfunctional (18 hours)**
required courses:
- Mgt 302 Quantitative Models-Conceptual (3)
- Mgt 321 Organizational Behavior Workshop (3)
- Acct 324 Cost Accounting (3)
- Fin 328 Corporate Financial Policy (3)
- Mkt 319 New Product Planning (3)
- Mkt 321 Business to Business Marketing (3)

Plus one of the following:
- IE 309 Introduction to Information Systems (3)
- IE 332 Product Quality (3)
- IE 334 Organizational Planning and Control (3)
Undergraduate Courses

Mgt 1. Introduction to Business Computing (3)
A one-semester survey of computer technology and software applications in business and economics. Topics include introduction to computer architecture and logic, operating systems, spreadsheets, and database management systems. Students will develop a working knowledge of microcomputers, mainframes and the campus-wide network. Limited to freshmen only.

Mgt 67. Business Writing Workshop (0)
Develops effective writing skills by building a conceptual foundation for business communication and practical application in organizational settings. Students attend weekly individual conferences with a Personal Writing Trainer for assessment and coaching on written assignments in other courses. Prerequisite: permission of department chair.

Mgt 101. Introduction to Quantitative Methods (3)
Mathematical concepts within a business and economics framework: linear algebra, partial derivatives, constrained optimization, and integral calculus. Meets mathematics prerequisite for entering students in the master of business administration program. Not available for credit to undergraduates in the College of Business and Economics.

Mgt 107. Introduction to Business Communications (2)
The communication process and strategic adaptation of language to meet cultural, institutional and personal needs within a changing business environment. Written and spoken communication through letters, memos, reports and oral presentations. Composition and design of informative, negative and persuasive messages. Nonverbal and interpersonal communications. Editing, revision, collaborative composition. Teamwork and interpersonal communication. Prerequisite: C- or better in English 1 and 2.

For Advanced Undergraduates and Graduate Students

Courses numbered 200 and above in the College of Business and Economics are open to sophomores only on petition.

Mgt 280. Management of People and Operations (4)
A total quality management perspective of managing people and operations in today's modern organizations. Lectures, case studies, and exercises. Major project required.

Mgt 301. Business Management Policies (3) fall, spring
Case study of business problems and the formulation of policies, strategies and tactics to resolve those problems from the viewpoint of general management. Long-range goal attainment, policy formulation, and administrative implementation for specific functional areas and the total firm. Prerequisite: senior standing in the College of Business and Economics, and completion of the college core. Barsness

Mgt 302. Quantitative Models-Conceptual (3)
Quantitative methodologies and their use in business, economics and related areas. Classical optimization techniques, mathematical programming, linear programming, decision theory, game theory, simulation and network models. Prerequisites: Eco 115, BIS 211.

Mgt 306. Entrepreneurship and Business Policy (3) spring
Case study of problems in creating new ventures or managing family-owned businesses. Integrates knowledge acquired in other courses and stresses development of strategic and administrative policies for particular functions and the company as a whole. Prerequisites: senior standing, completion of College of Business and Economics core, and Mgt 311, as well as approval of the department chair. Students may not receive credit for both Mgt 301 and 306. Bonge

Mgt 307. Business Communication Skills (3)
Written and spoken communication through letters, memos, reports, and oral presentations. Formal and informal communication networks, and communication processes. Prerequisite: consent of instructor.

Mgt 309. Industrial Purchasing and Materials Management (3)
Negotiating, purchasing, receiving, storing, inventory control, value analysis, procurement information systems, and specialized problems in institutional and government procurement. Lectures and cases. Bonge, Stevens

Mgt 311. LUMAC Management Assistance Counseling (3)
A field studies course providing management assistance to small businesses in the Lehigh Valley. Students work in small groups under faculty supervision on a direct basis with owners. Problem solving and experience in applying marketing, accounting, finance, and/or management concepts to business. Prerequisites: junior standing in the College of Business and Economics. Bonge, Stevens

Mgt 321. Organizational Behavior Workshop (3)
A workshop course examining individual behavior, interpersonal transactions and behavioral processes in small work groups through motivational analysis, role-playing nonverbal interactions, problem solving and group simulations. Prerequisites: Mgt 280, permission of the department chair. Poole, Kolchin, Litt

Mgt 333. Personnel Management (3)
Analysis and resolution of personnel problems in organizations. Human resource planning, recruitment, selection, orientation, training, appraisal, compensation, and development. Lectures and cases. Prerequisite: Mgt 280 Kolchin

Mgt 371. Directed Readings (1-3)
Readings in various fields of management designed for the student who has a special interest in some field of management not covered by the regularly scheduled courses. Prerequisite: consent of the department chair. May be repeated.

Mgt 372. Special Topics (1-3)
Special problems and issues in management for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of instructor and students. Prerequisite: consent of the department chair. May be repeated.

Course descriptions for the College of Business and Economics graduate courses can be found in this section (Section V) under the heading of Business and Economics Graduate Courses.

Management Science

The management science program is directed toward integrating scientific methods with the functional aspects of organizations by investigating the application of quantitative methodology and systems analysis in the context of such functional areas as production, finance, logistics, marketing and accounting. This integration provides the students with a broader perspective of managerial decision-making in both private enterprise and public administration.

Mid-career professionals or undergraduates with a background in engineering, mathematics, physical sciences or business and economics who intend to seek managerial, consulting or systems analyst positions are appropriate candidates. In particular, those candidates who intend to seek positions demanding both technical and management skills find
the management science background advantageous in dealing with the complex problems of industrial, commercial, and public service organizations.

The industrial and manufacturing systems engineering department administers the management science program. To be admitted to the program, a candidate must demonstrate basic competence in calculus, statistics, linear algebra, introductory operations research, accounting, finance, production and microeconomics. A candidate lacking a certain background may be required to take background courses. The minimum program consists of 30 credit hours of course work, of which at least 18 credit hours must be in the 400-level. All course work must be approved by the IMSE graduate faculty coordinator.

### Quantitative Courses
(at least 15 credit hours from the following list; no more than 6 credit hours in the 300-level)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
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<tbody>
<tr>
<td>IE 305</td>
<td>Simulation (3)</td>
</tr>
<tr>
<td>IE 316</td>
<td>Advanced Operations Research Techniques (3)</td>
</tr>
<tr>
<td>IE 328</td>
<td>Engineering Statistics (3)</td>
</tr>
<tr>
<td>IE 409</td>
<td>Data Dependent Systems (3), Prerequisite: basic statistics</td>
</tr>
<tr>
<td>IE 410</td>
<td>Design of Experiments (3), Prerequisite: basic statistics</td>
</tr>
<tr>
<td>IE 411</td>
<td>Networks and Graphs (3), Prerequisite: IE 316 or equivalent</td>
</tr>
<tr>
<td>IE 416</td>
<td>Dynamic Programming (3), Prerequisite: IE 316 or equivalent</td>
</tr>
<tr>
<td>IE 417</td>
<td>Advanced Mathematical Programming (3), Prerequisite: IE 316 or equivalent</td>
</tr>
<tr>
<td>IE 429</td>
<td>Modern Techniques in Combinatorial Optimization (3), Prerequisite: IE 316 or equivalent</td>
</tr>
<tr>
<td>IE 431</td>
<td>Operations Research Seminar (3)</td>
</tr>
<tr>
<td>Eco 351</td>
<td>Introduction to Mathematical Economics (3), Prerequisite: Eco 105 or 115 and 119</td>
</tr>
<tr>
<td>Eco 352</td>
<td>Advanced Statistical Methods (3), Prerequisite: Eco 1, 11 and 12</td>
</tr>
<tr>
<td>Eco 358</td>
<td>Game Theory (3), Instructor Approval Required</td>
</tr>
<tr>
<td>GBUS 431</td>
<td>Quantitative Financial Models (3), Prerequisite: GBUS 406</td>
</tr>
<tr>
<td>GECO 402</td>
<td>Managerial Economics (3), Prerequisite: GBUS 403 or equivalent</td>
</tr>
<tr>
<td>GECO 412</td>
<td>Mathematical Economics (3)</td>
</tr>
<tr>
<td>GECO 415</td>
<td>Econometrics I (3), Prerequisite: basic statistics</td>
</tr>
<tr>
<td>GECO 416</td>
<td>Econometric Theory (3), Prerequisite: GECO 412 and 415</td>
</tr>
<tr>
<td>GECO 460</td>
<td>Index Numbers and Time Series Analysis (3)</td>
</tr>
<tr>
<td>GECO 461</td>
<td>Forecasting (3)</td>
</tr>
<tr>
<td>GECO 462</td>
<td>Adv. Statistics for Business &amp; Economics (3), Prerequisite: Calculus</td>
</tr>
<tr>
<td>GECO 463</td>
<td>Topics in Game Theory (3), Instructor Approval Required</td>
</tr>
<tr>
<td>Math 334</td>
<td>Mathematical Statistics (3-4), Prerequisite: Math 231 or 309</td>
</tr>
<tr>
<td>GBUS 411</td>
<td>Managerial Policy and Decision Making (3), Instructor Approval Required</td>
</tr>
<tr>
<td>GBUS 451</td>
<td>Analytical Methods in Management (3)</td>
</tr>
</tbody>
</table>

### Functional Areas
(at least 12 credit hours from a chosen functional area) - prerequisites must be met for all CBE courses.

<table>
<thead>
<tr>
<th>Area</th>
<th>Example Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accounting</td>
<td>Acct 307, 309, 315, 316, 317, 324  GBUS 401, 407, 413, 414, 415, 416</td>
</tr>
<tr>
<td>Production &amp;</td>
<td>GBUS 401, 407, 413, 414, 415, 416  GBUS 408, 409, 460, 461, 462, 463, 464, 465, 466</td>
</tr>
<tr>
<td>Logistics</td>
<td>GBUS 408, 409, 460, 461, 462, 463, 464, 465, 466</td>
</tr>
</tbody>
</table>

### Additional Electives - (3 credit hours)
Courses suggested in above, plus others offered by the IMSE department, the College of Business and Economics and other related fields.

### Management of Technology

#### Program directors
Alden S. Bean, Ph.D. (Northwestern); Wm. R. Kenan, Jr. professor of management and technology and Theodore W. Schlie, Ph.D. (Northwestern), associate professor of technology management.

#### Program faculty
Keith Gardiner, Ph.D. (University of California), professor of industrial engineering; Benjamin Litt, Ph.D. (NYU), professor of management; Peter P. Poole, Ph.D. (Penn State), associate professor of management; Manash R. Ray, Ph.D. (Penn State), associate professor of accounting; Susan A. Sherer, Ph.D. (Pennsylvania), associate professor of management; Bruce M. Smackey, Ph.D. (Rensselaer), professor of marketing; John K. Smith, Ph.D. (Delaware), associate professor of history; Robert H. Storer, Ph.D. (Georgia Tech), associate professor of industrial engineering; Todd Watkins, Ph.D. (Harvard), associate professor of economics; Samuel C. Weaver, Ph.D. (Lehigh), associate professor of finance.

The program requires 37–39 credit hours of graduate work, including a thesis. It is designed for students with undergraduate degrees in science or engineering and several years of work experience in industries characterized by rapid technological change or whose firms compete on the basis of highly specialized knowledge. Students with undergraduate degrees in other fields will be considered based on industry experience, employer recommendations and other qualifications.

The program may be taken on a part-time basis, typically requiring two courses per semester over two calendar years; or as a full-time program that can be completed in one calendar year.

#### Required Course work
GBUS 402. Managerial Economics (3)  (Taken in conjunction with GECO 404)

GBUS 404. Technology, Trade and Economic Growth (1)  (Taken in conjunctions with GECO 402)
Overview of the role of technology in economic systems: productivity and growth effects, relationships to industry structure, impacts on international trade and competitiveness.

#### Financial Accounting Seminar
A two-day seminar developed as a refresher in basic accounting principals and standards and to introduce specific accounting issues influencing technology development. Offered by the MoT Program as a prerequisite for GBUS 406, 407 / MBA 402, 403.
GBUS 406. Financial Management (3) or MBA 402. Managing Financial Resources (4)
Introduction to financial management. Topics include: financial statement analysis, capital budgeting, capital structure, valuation, risk analysis and working capital management. Prerequisite: Financial Accounting Seminar.

GBUS 407. Managerial Accounting and Decision-Making (3) or MBA 403. Managing Information (4)
Traditional and emerging techniques of product costing; managerial accounting techniques for planning, control and decision-making; manufacturing and operational performance measures; quality management; cost management by product redesign. Prerequisite: GBUS 401 or Financial Accounting Seminar.

Hist 407. History of American Industrial Technology (3)
Origin and evolution of American technology and industry from the 19th century to the present. Investigates dynamics of major industries in national and international context.

GBUS 481. Technology, Operations, and Competitive Strategy (3)
Industry analysis and competitiveness; competitive strategy formulation and implementation; value chain analysis; operations and technology strategy; technology’s contribution to competitive advantages in quality, cost, variety, and new product availability; segmentation, substitution, and vertical integration.

GBUS 482. R, D, & E Project Management (3)
Management of cross-functional project teams for introducing technological innovations in the manufacturing and marketing of new products and services in a variety of industries; team leadership, communications, group dynamics, and project management techniques.

GBUS 483. R&D Management (3)
Developing R&D programs to achieve strategic business objectives; selecting, staffing, and managing R&D operations and transferring research results to commercial functions. Organization design for R&D and the impact of organizational forms and supervisory styles on R&D performance.

GBUS 484. Science and Technology Policies and Institutions (3)
The science and technology institutional infrastructure and its relationships with management decision-making, including: private, public (government), and quasi-public institutions; R&D, regulatory, and policy institutions; and U.S., foreign, and international institutions.

GBUS 486. Qualitative Research Methods (3)
Study of techniques that describe, decode, and translate social phenomena. Explores how interpretive researchers plan and conduct studies and present findings. Studies investigators’ roles, data sources, observation methods, data analysis methods, and trustworthiness of findings. A field research project is required.

Thesis
The master’s thesis is a capstone educational experience in which the knowledge students have acquired in the program is applied in a real world research setting. Ideally, this will involve field research in the form of a case study related to an aspect of managing the generation or implementation of innovative technology in the students’ organization or other field site.

Elective Courses
Three courses from the following list of recommended electives. Other elective courses may be taken with permission of MoT Advisor.

GBUS 409. Strategic Information Systems (3)
Study of the impact of information technology on business competition, organizational structure, and nature of work.

Explores development and management of information systems strategy, including economics and risks associated with investments in information technology. Case studies and applications include operations management, financial services, and marketing and distribution.

GBUS 465. New Product Planning in Marketing and Research and Development (3)
The design, development and marketing of new products and processes in high technology industries. Emphasis on the importance of patents and licensing; generation and screening of ideas; commercialization and technology transfer. Prerequisite: GBUS 401 or Financial Accounting Seminar.

GBUS 485. Diffusion and Implementation of Technology (3)
The adoption and diffusion of innovation, and managing the implementation/utilization/application of new technology in the organization. Emphasizes the organizational and cultural aspects of technology implementation and organizational change in technology intensive firms.

GBUS 4XX. Globalization and Management of Technology (3)
Management of science and technology in the context of international business and the globalization of markets, competition, and corporations. Management of global industrial R&D, technology-based global strategic alliances, global external technology sourcing, complex human resource and cross cultural issues, etc. Develops an appreciation of the scientific and technical capabilities available globally and the potential for global cooperative and/or competition in this regard.

GBUS 490. Thesis (3)

IE 442. Total Quality Management (3)
Principles and techniques of TQM; principles of Deming, Juran, Taguchi, and others; standards, metrics, costs, benchmarking, quality circles, and continuous improvement; Malcolm Baldrige and other awards, ISO 9000, case studies.

Manufacturing Systems Engineering


Program faculty. John P. Coulter, Ph.D. (Delaware), associate professor of mechanical engineering and mechanics; Mikell P. Groover, Ph.D. (Lehigh), professor of industrial and manufacturing systems engineering; Parveen P. Gupta, Ph.D. (Penn State), associate professor of accounting; Joseph C. Hartman, Ph.D. (Georgia Institute of Technology), assistant professor of industrial and manufacturing systems engineering; Louis Martin-Vega, Ph.D. (Florida), professor of industrial and manufacturing systems engineering; Roger N. Nagel, Ph.D. (Maryland), associate professor of mechanical engineering and engineering; Manas R. Ray, MBA (Indian Institute of Management - Calcutta), associate professor of accounting; Richard Roberts, Ph.D. (Lehigh), professor of mechanical engineering and mechanics; Guruswami Sathyaranayanan, Ph.D. (Michigan Tech), professor of industrial and manufacturing systems engineering; Bruce
M. Smackey, Ph.D. (Rensselaer), professor of marketing; Theodore Schlie, Ph.D. (Northwestern), associate professor of management of technology; Robert J. Trent, Ph.D. (Michigan State), assistant professor of management; George R. Wilson, Ph.D. (Penn State), associate professor of industrial and manufacturing systems engineering.

The manufacturing systems engineering program develops engineers who can design, install, operate, and modify systems involving materials, processes, equipment, facilities, logistics and people with leading edge technologies. It integrates systems perspectives with interdisciplinary course offerings from Lehigh's colleges of engineering and applied science, and business and economics. The 30-credit hour curriculum, leading to a master of science degree, may be structured as a one-year full-time program, beginning in January (some industrial experience is a requirement), or a two-year part-time program for working engineers within a 50-75 mile radius of campus. Courses in the part-time program are scheduled on Thursday evenings and all-day Friday in the spring and fall semesters. Seminars, plant tours, specially designed tutorials, and a one-week study tour of industry make up the non-credit program requirements.

Graduate Courses

MSE 421. Technology, Manufacturing & Competitive Strategy (3)
Interrrelations among advanced manufacturing management, technology and competitive strategy of the firm. Topics to include industry analysis and competitiveness; competitive strategy formulation and implementation; value chain analysis; manufacturing and technology strategy; manufacturing's contribution to competitive advantage in quality, cost, variety and new product availability; segmentation and substitution; vertical integration.

MSE 423. Product Design/Analysis (3)
Integrated approach to design and analysis of products and systems. Principles for robust design and use of computer-aided engineering to model, evaluate, and enhance design. Case studies and design assignments are major components of this course.

MSE 425. Production Planning and Resource Allocation (3)
Emphasis on the analysis, design and control of the logistics chain for manufactured goods. There is a focus on elements of time-based competition. Responsive delivery, short cycle times and reliable processes. Methods are discussed for aggregate and workforce planning, inventory control and machine scheduling are included.

MSE 427. Production Systems (3)
Modern production and assembly methods used in the mechanical and electrical/electronics industries. Techniques for deciding the most appropriate production method for a new product. Computer-aided process planning, group technology, robotics, numerical control, and other automated manufacturing methods.

MSE 429. Special Activities (0)
Seminars, plant tours, specially designed tutorials, and a one-week summer study tour of industry are non-credit requirements for completion of the MSE program. There is a one-time special activities fee ($2500 in 1999) to cover the cost of these activities.

MSE 431. Marketing & the Invention to Innovation Process (3)
Organizational issues and decision-making for capital investments in new technologies. The commercialization process is traced from research and development and marketing activities through the implementation phase involving the manufacturing function. Term project is a commercialization plan for a new manufacturing technology.

MSE 433. Technology and the Factory of the Future (3)
An MSE capstone course. Engineering and technological issues affecting future developments in manufacturing. Topics include flexible automation systems, integration of design and production through the factory data network, intelligent machines, the man-machine interface, and the manufacturing management information system.

MSE 438. Agile Organizations & Manufacturing Systems (3)
Analysis of the factors contributing to the success of manufacturing enterprises in an environment characterized by continuous and unpredictable change. Fundamentals of lean production: aspects of systems design, value stream analysis, flow, set-up and cycle time reduction, kaizen, elimination of waste. Fundamentals of agility: global enterprises, virtual organizations, adapting to change, mass customization, manufacturing flexibility, activity-based management.

MSE 446. International Supply Chain Management (3)
Financial and managerial issues. Evaluation, selection, development and management of suppliers; business models, financial reporting strategies, earnings, quality, risk assessment and internal control, team based new product development. Selected readings, case studies, discussions, lectures, group projects, and presentations.

MSE 451. Manufacturing Systems Engineering Project (1-3)

MSE 490. Manufacturing Systems Engineering Thesis (1-6)

MSE 496. Microelectronics Manufacturing Systems & Technologies (3)
Manufacturing engineering in electronics manufacture: crystal growth, doping, thin film deposition technologies and tooling, pattern generation techniques, contamination control, clean room practices, microelectronics assembly and packaging. Examination of systems design and operation issues.

Marketing

Professor. Bruce M. Smackey, Ph.D. (Rensselaer).
Associate professors. James E. Hansz, Ph.D. (Cincinnati); James M. Maskulka, D.B.A. (Kent State).
Assistant professor. Carolyn J. Simmons, Ph.D. (Florida).
Adjunct faculty. Therese A. Maskulka, D.B.A. (Kent State).

The field of marketing offers career opportunities for students in business, economics, liberal arts, engineering, and the physical sciences.

Marketing is pervasive in our society and is a critical function in the promotion of world trade. Creativity and the ability to conduct insightful analyses of competitive business situations are the hallmarks of a well-prepared student who can contribute to a prospective employer's organization. Undergraduates and graduates have been able to secure entry-level positions in a variety of marketing activities with firms in advertising and public relations, retail management, industrial sales and purchasing, bank marketing, marketing research, and new product design. Combining the marketing curriculum with related subjects in international relations, psychology and sociology, engineering, and history can often strengthen a student's capability to grow beyond his or her formal education period. Students are encouraged to explore the potential enhancement of their educational experience through study abroad programs, internships with business, and research projects with faculty members.

Participation in the Marketing Club student organization is an extracurricular activity that offers a professional orientation.
program and the enjoyment of socializing with other students from across the campus.

The marketing major offered by the Department of Management and Marketing consists of 15 credit hours from the following courses:

### Required courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mkt 312</td>
<td>Marketing Research</td>
<td>3</td>
<td>fall, spring</td>
</tr>
<tr>
<td>Mkt 313</td>
<td>Marketing Communications</td>
<td>3</td>
<td>fall, spring</td>
</tr>
</tbody>
</table>

### Elective courses

Three courses (nine credit hours) from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mkt 315</td>
<td>Consumer Behavior</td>
<td>3</td>
<td>fall, spring</td>
</tr>
<tr>
<td>Mkt 316</td>
<td>Advertising</td>
<td>3</td>
<td>fall, spring</td>
</tr>
<tr>
<td>Mkt 319</td>
<td>New Product Planning</td>
<td>3</td>
<td>fall, spring</td>
</tr>
<tr>
<td>Mkt 320</td>
<td>International Marketing</td>
<td>3</td>
<td>fall, spring</td>
</tr>
<tr>
<td>Mkt 321</td>
<td>Business to Business Marketing</td>
<td>3</td>
<td>fall, spring</td>
</tr>
<tr>
<td>Mkt 330</td>
<td>Retail Management</td>
<td>3</td>
<td>fall, spring</td>
</tr>
<tr>
<td>Mkt 360</td>
<td>Marketing Practicum</td>
<td>3</td>
<td>fall, spring</td>
</tr>
<tr>
<td>Mkt 371</td>
<td>Directed Readings</td>
<td>1-3</td>
<td>fall, spring</td>
</tr>
<tr>
<td>Mkt 372</td>
<td>Special Topics</td>
<td>1-3</td>
<td>fall, spring</td>
</tr>
</tbody>
</table>

### Undergraduate Courses

**Mkt 076. Marketing and Society** (3) fall, spring (Restricted to non-business students)

The role of marketing (exchange) and information technology in the creation of a global market society based upon knowledge are examined from the perspective of citizens, consumers, employees, and organizations. The course is designed for students outside the College of Business and Economics who desire to increase their knowledge of marketing and expand their career opportunities. Hansz

**Mkt 111. Contemporary Marketing** (3) fall, spring

The course examines contemporary marketing from a managerial perspective. Design of marketing programs within the context of consumer behavior, the social, economic, and cultural environment, market segmentation, demand, and industry structure. Prerequisite: Eco 1. Falcinelli

For Advanced Undergraduates and Graduate Students Courses numbered 200 and above in the College of Business and Economics are open to sophomores only on petition.

**Mkt 312. Marketing Research** (3) fall, spring

Quantitative and qualitative information in routine and nonrecurring decision-making. Statistical design of marketing studies, model building, analysis of research studies, and the development of marketing information systems. Case problems and presentation of student research projects examine problems in communicating research results. Prerequisites: Eco 145 and Mkt 111. Simmons, Hansz

**Mkt 313. Marketing Communications** (3) fall, spring

Communication-promotion decision processes of organizations. Impact of source, message and media variables on audience response to communication campaigns and the interactions among these variables. Role of personal selling, sales promotion, publicity, and advertising in marketing. Prerequisite: Mkt 111. Simmons

**Mkt 315. Consumer Behavior** (3)

Principal theories of psychology, social psychology, anthropology and economics which contribute to understanding the behavior and motivations of consumers. Consumer needs and wants; learning theory; the perceptual process; decision-making processes; communication; search behavior; market segmentation and product differentiation; and the adoption and diffusion of innovations. Prerequisites: Mkt 111 and Mkt 312. Simmons, Litt

**Mkt 316. Advertising** (3) spring

Analysis of advertising campaigns and the societal implications of advertising are considered from a managerial perspective. Prerequisite: Mkt 111. J. Maskulka

**Mkt 319. New Product Planning** (3) spring

Organization and management of marketing activities related to the development of new and improved products and services. The role of marketing research and product testing in the commercialization process. Application of risk analysis to the screening of ideas for new product candidates. Prerequisites: Mkt 111 and Fin 125/225. Smackey

**Mkt 320. International Marketing** (3) fall

The foreign market entry strategies firms may use are examined: export, contractual arrangements, and investment. Student companies implement each strategy in a multinational business game or through case analysis. Prerequisites: Fin 125/225 and Mkt 111. Hansz, J. Maskulka

**Mkt 321. Business to Business Marketing** (3) fall

The marketing of products and professional services from the firm to organizations; marketing principles applied to other than the ultimate customer in society; the role of salespersons as consultants to industrial customers and in professional fields such as banking, advertising, and management advisory services. Prerequisite: Mkt 111. Smackey

**Mkt 330. Retail Management** (3)

Full coverage of all major retailing topics including consumer behavior, marketing research, store location, service retailing, the retail audit, retail institutions, and international retailing. Students work in groups to conceptualize and develop a retail store of their choice. Prerequisites: Mkt 111 and Mkt 312. T. Maskulka

**Mkt 360. Marketing Practicum** (3) fall, spring

The marketing practicum combines formal classwork on marketing problem formulation and business communications with an intensive internship or consulting engagement with a business. Students work with client firms to develop individual or team projects, which focus on marketing activities such as market research, strategy development, sales management, and promotion management. Upon completion of the project, students submit a written report and make a formal presentation to clients. Prerequisites: Mkt 111, and either Mkt 312 or 313. Cannot be taken concurrently with Mkt 311.

**Mkt 371. Directed Readings** (1-3) fall, spring

Readings in various fields of marketing designed for the student who has a special interest in some field of marketing not covered in regularly scheduled courses. Prerequisite: consent of the department chair. May be repeated.

**Mkt 372. Special Topics** (1-3) fall, spring

Special problems and issues in marketing for which no regularly scheduled course work exists. When offered as group study or internship, coverage will vary according to the interests of the instructor and students. Prerequisite: consent of the department chair. May be repeated.

Course descriptions for the College of Business and Economics graduate courses can be found in this section (Section V) under the heading of Business and Economics Graduate Courses.
Materials Science and Engineering

Professors. David B. Williams, Ph.D. (Cambridge), Harold Chambers Senior Professor, chair; Charles E. Lyman, Ph.D. (M.I.T.), associate chair; G. Slade Cargill, Ph.D. (Harvard), Fairchild Chair; Helen M. Chan, Ph.D. (Imperial College of Science and Technology, England) New Jersey Zinc Professor; I. Alwyn Eades Ph.D. (Cambridge); Martin P. Harmer, Ph.D. (Leeds, England), Alcoa Professor, director of Materials Research Center, Himanshu Jain, Engr. Sci. D. (Columbia), Diamond Chair; Arnold R. Marder, Ph.D. (Lehigh); Michael R. Notis, Ph.D. (Lehigh); S. Kenneth Tarby, Ph.D. (Carnegie-Mellon), R.D. Stout Professor. Associate Professors. Wojciech Misiolek, Sc.D. (U. of Mining and Metallurgy, Krakow, Poland), Loevy Chair; Raymond A. Pearson, Ph.D. (Michigan); Jeffrey M. Rickman, Ph.D. (Carnegie-Mellon), Harold Chambers Junior Professor. Assistant Professor. Richard P. Vinci, Ph.D. (Stanford); John N. DuPont, Ph.D. (Lehigh). Adjunct professors. Lisa Friedersdorf, Ph.D. (Johns Hopkins); Brian R. Lawn, Ph.D. (Western Australia). Emeritus professors. Betzalel Avitzur, Ph.D. (Michigan); Sidney R. Butler, Ph.D. (Penn State); Ye T. Chou, Ph.D. (Carnegie Mellon); George P. Conard II, Sc.D. (M.I.T.); Richard W. Hertzberg, Ph.D. (Lehigh); Ralph I. Jaccodine, Ph.D. (Notre Dame); Allen W. Penske, Ph.D. (Lehigh); Donald M. Smyth, Ph.D. (M.I.T.); Robert D. Stout, Ph.D. (Lehigh); David A. Thomas, Sc.D. (M.I.T.); John D. Wood, Ph.D. (Lehigh).

Research engineers and scientists. David W. Ackland, Arlan O. Benscoter.

As science and technology advance in the 1990s and beyond, progress in many fields will depend on the discovery and development of new materials, processed in more complex ways, and with new kinds of properties. This has recently been demonstrated nicely by the development of superconducting ceramic materials. It is widely recognized that the progress of history has been divided into periods characterized by the materials that mankind has used, i.e., the stone age, the bronze age, the iron age. Today, materials science and engineering is critical to all other fields of engineering, and advances in these other fields are often limited by advances in materials.

Interest in new materials for solid-state devices, space technology, and superconductivity, as well as a better understanding of the behavior of materials in the design of structures, automobiles and aircraft, plant processing equipment, electrical machinery, etc., have increased the need for people trained in science and technology of materials.

Education for this field of engineering requires basic studies in mathematics, chemistry, physics and mechanics, plus a general background in engineering principles, followed by intensive training in the application of scientific and engineering principles to the development and use of materials in a technological society. In addition, the curriculum offers an introduction to humanistic and social studies; these broaden the student's outlook and enhance professional development after graduation.

The undergraduate program is designed to train graduates for research, development, operations, management and sales careers in industry or for graduate study in various specialties of the field, including the manufacture and applications of metals, ceramics, polymers, composites, and electronic materials. While some graduates go directly into materials-producing companies, a large proportion serve as engineers in the chemical, electrical, transportation, communications, space and other materials consumer industries. A number of students pursue graduate study leading to careers in research and teaching.

Mission statement: The materials science and engineering undergraduate program's mission is to provide its students an excellent education in a scholarly environment, and to have its graduates acquire the knowledge and experience needed to advance to successful careers and, where appropriate, for graduate study, in materials-related fields.

Major Requirements
The recommended sequence of courses is shown below. The standard freshman engineering year is shown in section III.

sophomore year, first semester (17 credits)*
Math 23 Analytic Geometry & Calculus III (4)
Phy 21, 22 Introductory Physics II and Laboratory (5)
Eco 1 Economics (4)
Mat 33 Engineering Materials and Processes (3) or
HSS Humanities/Social Sciences Elect(3)
Mat 10 Materials Laboratory (1)

*sMat 10 should normally be taken during the sophomore year. However, it may be taken in the first semester of the junior year.

sophomore year, second semester (17 credits)
Math 205 Linear Methods (3)
Mech 2 Elementary Engineering Mechanics (3)
Mat 203 Structure and Characterization of Materials (3)
Mat 205 Thermodynamics and Phase Diagrams (3)
Mat 207 Computational Methods in Materials Science (3)
Mat 33 Engineering Materials and Processes (3) or
HSS Humanities/Social Sciences Elect(3)

junior year, first semester (18 credits)
Elect. Elective (3)
HSS Humanities/Social Sciences Elect(3)
Chem 209 Chemistry of Materials (3)
Mat 216 Diffusion and Phase Transformations (3)
Mat 218 Mechanical Behavior of Materials (3)
HSS Humanities/Social Sciences Elect(3)

junior year, second semester (18 credits)
Mat 101 Professional Development (2)
Mat 204 Processing and Properties of Polymeric Materials (3)
Mat 206 Processing and Properties of Metals (3)
Mat 214 Processing and Properties of Ceramic Materials (3)
ECE 81 Principles of Electrical Engineering (4)
Elect. Elective (3)

senior year, first semester (16 credits)
Mat 201 Physical Properties of Materials (3)
Mat 325 Design, Selection, and Failure Analysis of Engineering Materials (4)
HSS Humanities/Social Sciences Elect(3)
IE 328 Engineering Statistics (3) or
Math 231 Probability and Statistics (3)

senior year, second semester (18 credits)
Mat 302 Electronic Properties of Materials (3)
Mat 338 Materials Reports (3)
Chem 60 Unit Operations Survey (3)
Elect. Elective (3)
Approved Elect. Approved Elective (3)**

**For the approved electives and/or engineering science electives, two courses should be taken from one of the following five specialization categories:

(1) Metals
Mat 312 Fundamentals of Corrosion
Mat 314 Advanced Metal Forming
Mat 317. Imperfections in Crystals
Mat 344. Metal Machining Analysis

(2) Ceramics
Mat 315. Physical Properties of Structural and Electronic Ceramics
Mat 335. Principles of Semiconductor Materials Processing
Mat 342. Inorganic Glasses
Mat 348. Materials Science for Electronic Applications
Mat 396. Chemistry of Nonmetallic Solids

(3) Polymers
Mat 393. Physical Polymer Science
Mat 388. Polymer Synthesis and Characterization Lab
Mat 309. Composite Materials

(4) Industrial Option*
Mat 327. Industrial Project (4)
Mat 329. Industrial Project (4)

(5) Research Option**
Mat 240. Research Techniques (3)
Mat 291. Undergraduate Research (3)

*The industrial option is designed to prepare students as plant materials engineers. The emphasis in Mat 327 and 329 is a team approach to the solution of actual plant problems. The courses are conducted in cooperation with local industries. Three days per week are spent at the plant of the cooperating industry on investigations of selected problems. The option is limited to a small group of seniors, selected by the department from those who apply. Summer employment is provided when possible for those who elect to initiate the program during the summer preceding the senior year.

**For those students who may be interested in research or development, and intend to pursue graduate work, a research option is offered. In this option, students take Mat 240 and 291. Financial support may be available for those students who elect to initiate a research program during the summer preceding the senior year. The option is limited to a small group of selected students.

Undergraduate Courses
Mat 10. Materials Laboratory (1) fall
Introduction to experimental methods used to fabricate and measure the structure and properties of materials. Thermal and mechanical processing and properties are emphasized. Specimen preparation and examination by optical microscopy. Prerequisite: Mat 33 previously or concurrently.

Mat 20. Computational Methods in Materials Science (2) spring
The use of computers and computational methods to solve problems in materials science and engineering. Students will employ both commercial packages and their own code in order to complete assignments. Students will utilize word processing and display packages to present results of projects. Prerequisite: Engr. I or equivalent. (ES 1), (ED 1)

Mat 33. Engineering Materials and Processes (3) fall-spring
Application of physical and chemical principles to understanding, selection, and fabrication of engineering materials. Materials considered include metals, polymers, ceramics, composites and electronic materials. Case studies of materials used range from transportation systems to microelectronic devices. Staff. (ES 2), (ED 1)

Mat 101. Professional Development (2) fall
Seminar on the role and purpose of engineering in society; the meaning of being a professional; the role of creativity, communications and decision-making in the engineering process; expectations and problems of young engineers; personal goals; choosing a career. Required reading. Written reports based on library research. Prerequisite: junior standing. (ED 1)

Mat 107. Special Topics in Materials (1-3)
A study of selected topics in materials science and engineering not covered in other formal courses.

Mat 192. Structural Materials (3) fall
The major classes of materials metals, ceramics and concrete, polymers, and composites with emphasis on their suitability for structural applications. The dependence of material properties on atomic bonding, microstructure, processing, and service conditions. Some laboratories on determination of mechanical properties. Required for civil engineering students. Prerequisite: Mech 12. Hertzberg. (ES 3)

For Advanced Undergraduates and Graduate Students
Mat 201. Physical Properties of Materials (3) fall
Basic concepts of modern physics and quantum mechanics needed for an understanding of electrons in solids. The experimental development leading to wave mechanics is emphasized. Uses of the Schrodinger equation as the basis for the free electron theory of metals and band theory. Optical properties are developed leading to a discussion of lasers. Prerequisites: Phys 21, Mat 33, Math 205. Jain. (ES 2.5), (ED 0.5)

Mat 203. Structure and Characterization of Materials (3) spring
Atomic structure and types of bonding. Crystalline and amorphous states. Crystal structures, and fundamental aspects of crystallography (space lattice, Miller indices, symmetry elements). Crystal defects (point, line and planar). Basic principles of structure determination by x-ray diffraction. Microscopical techniques (light and electron optical), and their application to material characterization. Prerequisites: Chem 21; Mat 10 and Mat 33 previously or concurrently. Chan, Lyman, Notis, Williams. (ES 3)

Mat 204. Processing and Properties of Polymeric Materials (3) spring
The structure-property relationships in polymers will be developed, emphasizing the glass transition, rubber elasticity, crystallinity, and mechanical behavior. Elements of polymer processing. Extrusion of plastics and films, and fiber spinning operations. Lectures and laboratories. Prerequisite: Chem 209 or one semester of organic chemistry. Pearson. (ES 1.5), (ED 1.5)

Mat 205. Thermodynamics and Phase Diagrams (3) spring
The three laws of thermodynamics. Gibbs free energy and thermodynamic basis for equilibrium. Solution thermodynamics. Binary and ternary equilibrium phase diagrams. Application of thermodynamics to materials problems. Lectures and laboratories. Prerequisite: Math 23 and Mat 33 or equivalent. Tarby. (ES 3)

Mat 206. Processing and Properties of Metals (3) spring
The production and purification of metals, their fabrication, and control of their properties. Includes topics such as precipitation hardening, hot and cold working, and casting. Lectures and laboratories. Prerequisite: Mat 205. Marder. (ES 1), (ED 2)

Mat 214. Processing and Properties of Ceramic Materials (3) spring
Mat 216. Diffusion and Phase Transformations (3) fall
Fundamental diffusion equations; liquid-solid transformations; solid-solid transformations; transformation kinetics; metastable transformations; diffusionless transformations; examples of various transformations in different materials and their effect on properties. Prerequisites: Mat 203, Mat 205. Williams, Notis, Barmak. (ES 2), (ED 1)

Mat 218. Mechanical Behavior of Materials (3) fall
Deformation and fracture behavior of materials. Elastic and plastic behavior, with emphasis on crystallographic considerations. Strengthening mechanisms in solids. Static and time-dependent fracture from microstructural and fracture mechanics viewpoints. Fatigue failure. Prerequisites: Mech 2, Mat 203, and Mat 33. Hertzberg, Pearson, Chan. (ES 1.5), (ED 1.5)

Mat 221. (STS 221) Materials in the Development of Man (3)
Development of materials technology and engineering from the stone age to atomic age as an example of the interaction between technology and society. In-class demonstration laboratories on composition and structure of materials. Term projects using archaeological materials and alloys. Course intended for, but not limited to, students in the humanities and secondary science education. Engineering students may not use this course for engineering science or technical elective credit.

Mat 240. Research Techniques (3)
Study and application of research techniques in materials science and engineering. Research opportunities, design of experimental programs, analysis of data, presentation of research. Selection of research topic and preparation and defense of research proposal. Restricted to a small number of students selected by the department from those who apply. (ES 3)

Mat 291. Undergraduate Research (3)
Application of research techniques to a project in materials science and engineering selected in consultation with the faculty. Normally preceded by Mat 240.

Mat 302. Electronic Properties of Materials (3) spring
The electronic structure of materials, i.e., band and zone theory, is presented from a physical point of view. Electrical conductivity in metals, semiconductors, insulators and superconductors is discussed. Simple semiconductor devices reviewed. Magnetic properties are examined in the context of domain theory and applications are discussed. Optical and dielectric properties of semiconductors and ferroelectrics are considered. Prerequisites: Mat 30, Mat 201, Mat 203. Jain, Notis. (ES 2), (ED 1)

Mat 309. Composite Materials (3)
The principles and technology of composite materials. Processing, properties, and structural applications of composites, with emphasis on fiber-reinforced polymers. Lectures and some field trips or laboratories. Prerequisite: Mat 30 or equivalent. Mech 2. (ES 2), (ED 1)

Mat 310. Independent Study in Materials (1-3)
Provides an opportunity for advanced, independent study of selected topics in materials science and engineering not covered in other formal courses.

Mat 312. (Chf 312, Chem 312) Fundamentals of Corrosion (3)

Mat 314. Advanced Metal Forming (3)
Extension of Mat 303. Topics to be included: friction, lubrication and wear, failure and damage in metal forming, and deformation in composite metals and in powder metallurgy. Forming alternatives for specific products such as cans, tubes, wires and others will be compared. Recent developments of new forming processes. Prerequisite: Mat 325. (ES 1), (ED 2)

Mat 315. Physical Properties of Structural and Electronic Ceramics (3)
Structure-property relationships in ceramics. Mechanical behavior including plasticity, hardness, elasticity, strength and toughness mechanisms. Thermal behavior including specific heat, thermal expansion, thermal conduction and thermal shock. Electrical behavior including application of tensors and crystal physics to electrophysics. Prerequisites: Mat 214 or consent of instructor. Harmer. (ES 3)

Mat 317. Imperfections in Crystals (3)
The major types of crystal defects and their role in controlling the properties of materials. Point, line and planar defects, their atomic configurations and experimental techniques to study their characteristics. Emphasis on the role of dislocations and grain boundaries in the control of mechanical properties. Prerequisite: Mat 203 or consent of instructor. Rickman. (ES 3)

Mat 318. Mechanical Behavior of Materials (3) fall
Deformation and fracture behavior of materials. Elastic and plastic behavior, with emphasis on crystallographic considerations. Strengthening mechanisms in solids. Static and time-dependent fracture from microstructural and fracture mechanics viewpoints. Fatigue failure. Prerequisites: Mech 2, Mat 203, and Mat 33. Hertzberg, Pearson, Chan. (ES 1.5), (ED 1.5)

Mat 319. Current Topics in Materials Science (3)
Selected topics of current interest in the field of materials engineering but not covered in the regular courses. May be repeated for credit with consent of the department chair. Prerequisite: Consent of department chair. (ES 3)

Mat 320. Analytical Methods in Materials Science (3)
Selected topics in modern analysis and their application to materials problems in such areas as thermodynamics, crystallography, deformation and fracture, diffusion. Prerequisite: Math 231 or 205. Rickman. (ES 3)

Review of different classes of engineering materials and mechanical stress states experienced by structural components. Failure analysis and prevention of engineering component failure. Introduction to product liability litigation. Problem solution-oriented selection and design of materials with appropriate fabrication, thermal, and surface finish processes. Lectures plus laboratories which require individual design and execution of experiments to solve both materials selection and failure analysis problems. Prerequisites: Mat 204, Mat 206, Mat 214, and Mat 218. Marder (ES 1), (ED 3)

Mat 327. Industrial Project (4) fall
Restricted to a small group of seniors and graduate students selected by the department from those who apply. Three full days per week are spent on development projects at the plant of an area industry, under the direction of a plant engineer and with faculty supervision. Tarby, Chan, Lyman (ED 4)

Mat 329. Industrial Project (4) fall
To be taken concurrently with Mat 327. Course material is the same as Mat 327. (ED 4)

Mat 333. (EES 337, Chem 337) Crystallography and Diffraction (3)
Introduction to crystal symmetry, point groups, and space groups. Emphasis on materials characterization by x-ray diffraction and electron diffraction. Specific topics include crystallographic notation, stereographic projections, orientation of single crystal, textures, phase identification, quantitative analysis, stress measurement, electron diffraction, ring and spot patterns, convergent beam electron diffraction (CBED), and
space group determination. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Lectures and laboratory work. Prerequisites: Mat 203 or EES 133 or senior standing in chemistry. Lyman, Chan. (ES 3)

Mat 334. (EES 338, ChE 334) Electron Microscopy and Microanalysis (4) fall Fundamentals and experimental methods in electron optical techniques including scanning electron microscopy (SEM), conventional transmission (TEM) and scanning transmission (STEM) electron microscopy. Specific topics covered will include electron optics, electron beam interactions with solids, electron diffraction and chemical microanalysis. Applications to the study of the structure of materials are given. Prerequisite: consent of the department chair. Williams, Lyman. (ES 4)

Mat 335. (ChE 335) Principles of Semiconductor Materials Processing (3) Description and analysis of the processing steps involved in microelectronic material fabrication. Emphasis will be placed on the chemical and physical reaction phenomena, and interpretation of experimental methods and data. Prerequisite: thermodynamics and senior standing. (ES 3)

Mat 338. Materials Reports (3) spring Written and oral communication through various types of reports and talks. Evaluation on both technical content and quality of presentation. Use of information sources, graphics, and visual aids. Videotaping and peer critique of oral presentations. Prerequisite: senior standing.

Mat 342. Inorganic Glasses (3) Definition, formation and structure of glass; common glass systems; manufacturing processes; optical, mechanical, electrical and dielectric properties; chemical durability; glass fibers and glass ceramics. Lectures and laboratories. Prerequisite: Mat 33. Jain, Chan. (ES 3)

Mat 344. (IE 344) Metal Machining Analysis (3) Intensive study of metal cutting emphasizing forces, energy, temperature, tool materials, tool life, and surface integrity. Abrasive processes. Laboratory and project work. Prerequisite: IE 115 or ME 240 or Mat 206. (ES 2), (ED 1)

Mat 348. Materials Science for Electronic Applications (3) Materials technology for integrated circuit packaging systems. Dielectric, thermal and mechanical considerations; joining methods; resistor and ceramic capacitor materials and incorporation of active devices into packaging systems; multilayer package design and processing. Individualized semester project involving forensic examination of failures using scanning electron microscopy and microprobe analysis. Prerequisite: Mat 201, and Mat 33. Notis. (ES 2), (ED 1)

Mat 367. (ChE 367) Metal Films and Coatings: Processing, Structure, and Properties (3) Focus will be on the processing, structure, and properties of metal films and coatings. Processing methods will include evaporation, sputtering, chemical vapor deposition (CVD), plasma-assisted CVD, ion implantation, electrodeposition, metal bath solidification, weld overlay, thermal spraying, and diffusion. Characterization of thin films and coatings will be done with the use of sophisticated analytical instrumentation, including spectroscopic methods, microscopy and diffraction techniques. Characterization methods are explored in conjunction with processing techniques and film/coating properties via class assignments that are designed to introduce students to the archival scientific literature. Prerequisite: Senior standing in chemical engineering or materials science and engineering, or permission of the instructor(s). (ES 1.5), (ED 1.5)

Mat 388. (ChE 388, Chm 388) Polymer Synthesis and Characterization Laboratory (3) spring Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisite: Senior level standing in chemical engineering, chemistry, or materials science and engineering, or permission of the instructor. (ES 2), (ED 1)

Mat 393. (ChE 393, Chm 393) Physical Polymer Science (3) Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline states (including viscoelastic and relaxation behavior) for single- and multicomponent systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology and behavior. Prerequisite: Senior level standing in Chemical Engineering, Chemistry, or Materials Science and Engineering, or permission of the instructor. (ES 1.5), (ED 1.5)

Mat 396. (Chem 396) Chemistry of Nonmetallic Solids (3) Chemistry of ionic and electronic defects in nonmetallic solids and their influence on chemical and physical properties. Intrinsic and impurity-controlled defects, nonstoichiometric compounds, defect interactions. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, and photovoltaic. Prerequisite: Chem 187 or Mat 205 or equivalent. (ES 3)

For Graduate Students

The department offers three degrees; a master of science, a master of engineering, and a doctor of philosophy in science and materials engineering.

While a diversity of programs and curricula are available to a person interested in graduate study in the area of materials, generally the degree is earned in the Department of Materials Science and Engineering. However, thesis and dissertation research may be a part of programs under way in the department or at the Materials Research Center or other departments or centers.

The department has a large enough staff and graduate enrollment to enable it to suit the needs of students whose interests range from the science of materials through materials engineering. At the same time, those advanced students who want experience in teaching are able to teach under the guidance of the senior staff.

The foundation for successful graduate work in the department includes sound preparation in chemistry, physics and mathematics, and adequate breadth of general education. Candidates entering the department who have obtained their previous degrees in fields other than materials may be required to take certain undergraduate courses without credit toward the graduate degree.

The programs of the department are flexible. Upon acceptance, each student is assigned a faculty adviser. Under the adviser's direction, the student plans a course of study to satisfy individual needs and interests.

Most advanced-degree recipients find careers in industry or industrial or governmental research and development laboratories. A smaller number have gone into teaching, consulting or academic research.

Graduate facilities for research are located in the Whitaker Laboratory, in the interdisciplinary Materials Research Center, the Sherman Fairchild Laboratory, and other associated laboratories. The laboratories are well equipped with both generalized equipment as well as sophisticated research equipment.

Specialized equipment such as conventional and scanning transmission electron microscopes, scanning electron
microscopes, electron microprobe, X-ray diffraction units, closed-loop mechanical testing equipment, and crystal-growing and zone-processing equipment are maintained and operated by skilled technicians. After receiving the required instructions, graduate students operate this equipment.

Departmental facilities are supplemented by central computer facilities, microcomputers, and a fine science and engineering library.

Special Programs and Opportunities
The department has established specific recommended programs for the M.S., the M.Eng., and the Ph.D., emphasizing the following areas: electron microscopy and microanalysis of all materials, physical metallurgy, ceramics, polymers and composites, mechanical behavior, electronic materials, and manufacturing processes.

These programs are flexible. Students in an area such as fracture may work in the department or in cooperation with the Materials Research Center or the Department of Mechanical Engineering and Mechanics. The ceramics program emphasizes the study of the electrical and mechanical behavior of various ceramic systems. The study of solid-state materials for electronic applications is done largely in the Sherman Fairchild Laboratory. The department also cooperates with the chemical engineering and chemistry departments in the graduate polymer science and engineering program.

Major Requirements
The requirements are explained in Section IV. In the Department of Materials Science and Engineering, a candidate for the M.S. completes a thesis. This normally represents six of the 30 semester hours required for this degree. Candidates for the M.Eng. complete a three-credit engineering project.

A candidate for the Ph.D. prepares a preliminary program of courses and research, providing for specialization in some phase of the field (largely through research) in consultation with the adviser. Prior to formal establishment of the doctoral program by the special committee and its approval by the college, the student passes a requiring examination that must be taken early in the first year of doctoral work. The department does not require a foreign language. It does require preparation and defense of a research proposal as a portion of the general examination.

Of the courses listed above only those in the 300 series are available for graduate credit. There are many additional offerings in materials under the listings of other departments.

Most graduate students receive some form of financial aid. Several kinds of fellowships and assistantships are available. This type of aid generally provides for tuition, an allowance for experimental supplies, and a stipend. For details of graduate scholarships, fellowships and assistantships, please refer to Section IV.

Research Activities
Graduate students conduct their research in facilities located in the department or the Materials Research Center, or other centers and institutes. The following list of activities notes the many areas of interest. Asterisks (*) indicate research of an interdisciplinary nature.

Materials science. Crystal growth*; defect chemistry and electrical properties of insulating and semiconducting oxides*; growth and deformation of bicrystals; dislocation studies; meteorites and lunar materials; processing of metal insulator semiconductor structures and their evaluation and application to integrated circuits*; quantitative metallography; structure and behavior of solid-state materials.*

Mechanical behavior. Correlation of microstructure with mechanical behavior of low-alloy, high-strength steels; deep drawing, impact extrusion and ironing; electron fractography*; environmental crack kinetics*; fatigue crack propagation studies of metals and polymers*; flow through converging conical dies; friction measurement; theoretical analysis of metal-forming methods and correlation with metallurgical parameters; toughness of weld metal; weldability of steels.

Ceramics. Electrical properties of electronic ceramics*; hot pressing studies*; grain growth in oxides*; electrical and magnetic properties of oxides*; creep modeling of ceramics; electron microscopy of dislocation structures; defect chemistry and electrical properties of ceramic oxides and glasses*; deformation equations, and fracture and fracture of structural ceramics and ceramic composites.*

Physical metallurgy. Brittle fracture characteristics and fatigue properties of low-alloy, high-strength steels*; diffusion-controlled growth; kinetics of solid-state reactions*; physical metallurgy of aluminum alloys; strengthening mechanisms; structure and morphology of martensite; ternary diffusion; transformation during joining; transmission electron microscopy of crystal defects.

Polymers. Environmental effects on polymers*; fatigue crack propagation in engineering plastics*; fracture surfaces of crystalline polymers*; ion transport in polymer membranes; mechanical behavior of interpenetrating networks*; mechanical behavior of polyvinyl chloride*; micromechanics of polymer fracture*; polymers from renewable resources; properties of polymer composites*; reclamation of scrap polymeric materials*; viscoelastic damping.

Chemical metallurgy. Mathematical modeling of metallurgical processes; thermodynamics of metallic solutions; thermodynamics and phase equilibria.

Electronic materials. Origin and properties of defects in semiconductors and insulators; processing of materials used in VLSI device structures; processes studied include ion implantation, rapid thermal processing, chemically-enhanced oxidation, LPCVD, sputtering, and plasma etching and deposition.

Graduate-Level Courses
Mat 401. Thermodynamics and Kinetics I (3) fall

Mat 402. Thermodynamics and Kinetics II (3) spring
Continuation of Mat 401. Derivation of fundamental diffusion equations, and their application to single and multicomponent systems. Theoretical models of nucleation and growth (including spinodal decomposition), and comparison with experimental observations. Kinetics of solid state transformations, including phase transformations and particle coarsening.

Mat 403. Structure and Properties I (3) fall
The underlying principles of the structure of materials and relationship to properties. Mathematical foundations such as applications of partial differential equations, and group theory and tensor properties. Crystal structure including symmetry, point and space groups, and crystal symmetry and properties. Study of recent reviews and classic sources.

Mat 404. Structure and Properties II (3) spring
Continuation of Mat 403. Defects in crystals in relationship to properties, including point, line, and planar defects. Noncrystalline structure including covalent-ionic, metallic, and polymeric glasses; related concepts such as short-range order and fractal geometry. Concludes with student presentations on important topics from Mat 403 and 404.

Mat 406. Solidification (3)
Solidification phenomena in pure, single and multiphase materials including the nature of the freezing interface, segregation, constitutional supercooling, dendritic growth, crystallographic effects, the origin of defects, crystal growing, zone processes. Prerequisite: consent of the chairperson.

**Mat 408. Transformations (3)**

The thermodynamic, kinetic and phenomenological aspects of a wide spectrum of solid-state phase transformations. Theories of nucleation, growth and coarsening of second-phase precipitates. Application of the theories to continuous and discontinuous reactions, massive, martensitic and bainitic transformations in metals. Transformations in nonmetals. Prerequisite: Mat 205 and 216 or equivalent. Marder, Smith, Williams

**Mat 409. Current Topics in Materials (3)**

Recent practical and theoretical developments in materials. This course may be repeated for credit if new material is covered. Prerequisite: consent of the department chair.

**Mat 410. Physical Chemistry of Metals (3)**

Discussions of reactions involving gases and reactions involving pure condensed phases and a gaseous phase. Ellingham diagrams and equilibria in metal-oxygen-carbon systems. Consideration of the behavior of solutions and methods for determining thermodynamic properties of solutions by experiment and computation. Prerequisite: Mat 205 or equivalent. Tarby

**Mat 411. Modern Joining Methods (3)**

The foundations upon which the joining processes rest; the present limitations of the various processes; the trends in new developments; the engineering and structural aspects of joining. Prerequisite: Mat 216 and 218 or equivalent. Pense

**Mat 412. Magnetic Properties of Materials (3)**

Fundamental concepts of magnetism and magnetic properties of ferro- and ferrimagnetic materials. Metallic and nonmetallic materials. Current application areas considered as examples. Prerequisite: Phys 31 or 363 or equivalent. Notis, Barmak

**Mat 413. Analysis of Metal Forming Processes (3)**

Three-dimensional stress and strain analysis. Yield criteria, plastic flow and the upper and lower bound theorems. Analysis of metal forming processes, including drawing and extrusion, press work, rolling and spinning. The emphasis is on presenting several approaches to each problem.

**Mat 415. Mechanical Behavior of Ceramic Solids (3)**

Strength, elasticity, creep, thermal stress fracture, hardness, abrasion and high-temperature deformation characteristics of single- and multi-component brittle ceramic solids. Statistical theories of strength, static and cyclic fatigue, crack propagation, fracture toughness. Correlation of mechanical behavior, microstructure, and processing parameters. Prerequisite: Mat 218 or consent of the department chair. Notis, Harmer

**Mat 416. Atom Movements (3)**

Phenomenological and atomistic development of the laws of diffusion and their solution. Influence of gradients of concentration, potential, temperature and pressure. Effects of structural defects on diffusion in metals and nonmetals. Prerequisite: Math 23 and Mat 205 or the equivalent.

**Mat 417. Deformation and Strength of Solids (3)**

Topics related to deformation of solids including creep, strengthening mechanisms, annealing of deformed solids, preferred orientation. Primary emphasis is on crystalline materials. May be repeated for credit if different material is covered. Prerequisite: Mat 218 or equivalent. Hertzberg, Notis

**Mat 418. Fatigue and Fracture of Engineering Materials (3)**


**Mat 419. Advanced Physical Metallurgy (3)**

Application of physical metallurgy principles to materials systems. Transformation structures and the influence of morphology on properties. Alloy design and heat treatment for improved strength, toughness, creep, corrosion resistance, electrical and magnetic properties. Prerequisite: Mat 325 or equivalent. Marder

**Mat 421. Fracture Analysis (3)**

Application of fracture mechanics concepts, microstructural analysis, and fracture surface characterization to the analysis and prevention of engineering component failures. Extensive use of case histories. Introduction to legal aspects of product liability. Prerequisite: Mat 218 or Mech 313 or equivalent. Hertzberg

**Mat 423. Advanced Transmission Electron Microscopy (4)**

The theory and practice of operation of the transmission and scanning transmission electron microscope. Techniques covered include bright field, high resolution and weak-beam dark field, lattice imaging, diffraction pattern indexing and Kikuchi line analysis. The theory of diffraction contrast is applied to the interpretation of electron micrographs. Specimen preparation techniques. Prerequisite: Mat 334 or equivalent. Williams

**Mat 425. Topics in Materials Processing (3)**

Topics such as: ceramics, metal, and polymer synthesis and compaction phenomena. Theories of sintering and grain growth. Physical behavior of sintered compacts. Techniques of fiber and crystal growth. Vapor deposition and ultra-high-purity materials preparation. Desirable preparation: Mat 204 or 206 or 214, and Mat 218. Prerequisite: consent of the department chair.

**Mat 427. Advanced Scanning Electron Microscopy (4)**

The theory and practice of operation of the scanning electron microscope and electron microprobe. Techniques covered will include high-resolution scanning, quantitative electron probe microanalysis. Electron beam sample interactions, X-ray spectrometry, and electron optics will be discussed in detail. Prerequisite: Mat 334 or equivalent.

**Mat 429. Dielectric and Electrical Properties of Ceramics (3)**

Basic concepts of dielectric and electrical phenomena in ceramics including dielectric loss, dielectric breakdown, ferroelectricity, piezoelectricity, mixed conduction, and interfacial effects. Physical and materials aspects of technologically important ceramics such as thermistors, varistors, boundary layer capacitors, solid electrolytes, gas sensors, glasses, etc. Prerequisite: Mat 201 or equivalent. Jain

**Mat 430. Glass Science (3)**

Definition and formation of glass. Structure of common inorganic (including metallic) and polymeric glass systems. Methods of glass making. Phase separation of devitrification. Physical properties including diffusion, electrical conductivity, chemical durability, and optical and mechanical properties. Special products including glass ceramics, optical fibers, photosensitive glasses, etc. Visit to a glass manufacturing plant may also be included. Prerequisite: Mat 315 or equivalent. Jain

**Mat 431. Sintering Theory and Practice (3)**

Science and technology of the sintering of solid-state materials. Driving force and variables. Critical review of the sintering
models. Coverage of single phase, multiphase and composite systems. Special sintering techniques such as fast firing, rate controlled sintering, hot pressing and transient second-phase sintering. Sintering of specific ceramic and metal systems. 
Prerequisite: Mat 214 or equivalent. Harmer

Mat 432. Theories of Silicon Oxidation (3)
A critical review is given of advanced theories of silicon oxidation. Present accepted theory (Deal-Grove) is inadequate for explaining thin (state-of-the-art >200) oxides. Course will consider most recent approaches to theory of thin gate insulators. It will also include new experimental approaches that use “impurity gaseous doping” and halogen additions.

Mat 437. (Mech 437) Dislocations and Strength in Crystals (3)
Theory and application of dislocations. Geometrical interpretation; elastic properties; force on a dislocation; dislocation interactions and reactions; multiplication. Dislocations in crystal structures. Selected topics in strengthening, plastic flow, creep, fatigue and fracture are discussed. Prerequisite: Math 205 or 231, or Mat 320; Mat 317, or consent of the department chair. Wei

Mat 443. (Chem 443) Solid-State Chemistry (3)
Crystal structure, diffraction in crystals and on surfaces, bonding and energy spectra in solids, dielectrics, surface states and surface fields in crystals. Prerequisites: one course in linear algebra and one course in quantum mechanics. Klier

Mat 458. Materials Design (3)
Analysis of design requirements for materials components. Selection of materials and processes. Study of failures in process and service and application of recent metallurgical and materials engineering knowledge for improved design. Solution and discussion of industrial problems, and outline of experimental approach. Prerequisite: consent of the chair.

Mat 460. Engineering Project (1-3)
In-depth study of a problem in the area of materials engineering or design. The study is to lead to specific conclusions and be embodied in a written report. Intended for candidates for the M.Eng. May be repeated for a total of three credit hours.

Mat 461. Advanced Materials Research Techniques (3)
Study of the theory and application of selected advanced techniques for investigating the structure and properties of materials. May be repeated for credit with the approval of the department chair.

Mat 482. (Chm 482, ChE 482) Engineering Behavior of Polymers (3) spring
A treatment of the mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analog. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticiizers, moisture and aging on mechanical behavior.

Mat 485. (Chm 485, ChE 485) Polymer Blends and Composites (3) fall
Synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers are emphasized. Prerequisite: any introductory polymer course or equivalent.

Mathematics

Professors. Donald M. Davis, Ph.D. (Stanford); Bennett Eisenberg, Ph.D. (M.I.T.); B. K. Ghosh, Ph.D. (London); Samuel L. Gulden, M.A. (Princeton); Wei-Min Huang, Ph.D. (Rochester); Samir A. Khabbaz, Ph.D. (Kansas); Jerry P. King, Ph.D. (Kentucky); George E. McCluskey, Jr., Ph.D. (Pennsylvania), chair and head of the Division of Astronomy; Eric P. Salathe, Ph.D. (Brown), director of the Institute for Biomedical Engineering and Mathematical Biology; Murray Schechter, Ph.D. (N.Y.U.); Andrew K. Snyder, Ph.D. (Lehigh); Lee J. Stanley, Ph.D. (Berkeley); Gilbert A. Stengle, Ph.D. (Wisconsin) head of the Division of Applied Mathematics and Statistics; Joseph E. Yukich, Ph.D. (M.I.T.).

Associate professors. Bruce A. Dodson, Ph.D. (S.U.N.Y. at Stony Brook); Vladimir Dobric, Ph.D. (Zagreb, Croatia); Garth Isaak, Ph.D. (Rutgers); David L. Johnson, Ph.D. (M.I.T.); Terrence Napier, Ph.D. (Chicago); Clifford S. Queen, Ph.D. (Ohio State); Susan Szczepanski, Ph.D. (Rutgers); Ramamirthan Venkataraman, Ph.D. (Brown).

Adjunct professor. Howard Fegan, Ph.D. (Oxford).

Mathematics is the universal language of science, and is essential for a clear and complete understanding of virtually all phenomena. Mathematical training prepares a student to express and analyze problems and relationships in a logical manner in a wide variety of disciplines including the physical, engineering, social, biological, and medical sciences, business, and pure mathematics itself. This is a principal reason behind the perpetual need and demand for mathematicians in education, research centers, government, and industry.

The department offers three major programs leading to the degrees of bachelor of arts in mathematics, bachelor of science in mathematics, and bachelor of science in statistics. It also offers five minor programs for undergraduates.

The Division of Astronomy and the Division of Applied Mathematics and Statistics are parts of the Department of Mathematics. Details on these divisions may be found in separate listings in the catalog.

Calculus Sequences
There are six calculus sequences: Math 21, 22, 23; Math 31, 32, 33; Math 51, 52. The 21-23 sequence and the 31-33 sequence cover roughly the same material, but the 31-33 sequence does it in more depth and with more rigor. The 31-33 sequence should be considered by students who have demonstrated exceptional ability in mathematics. Students who may wish to consider the 31-33 sequence include those in science and engineering and those who are contemplating a possible major in mathematics. Most students of science and engineering will take the 21-23 sequence. The 31-33 sequence will be accepted in place of either of the other sequences, and 21-23 will be accepted in place of 51-52. Math 51 and 52 are designed primarily for students in business and the biological sciences. Credit will be awarded for only one course in each of the following groups: 21, 31, and 51; 22, 32, and 52; 23 and 33. If two courses in the same group are taken, credit will be given for the more advanced course; 3x is the most advanced, while 5x is the least advanced.

B.A. in Mathematics

The B.A. program in mathematics emphasizes fundamental principles as well as the mastery of techniques required for the effective use of mathematics. The program has the flexibility and versatility needed to prepare students for careers in government, industry and education. The program provides a solid foundation for those who want to pursue advanced study in any mathematically oriented field.

The program involves a total of 121 credit hours, 42 of which are in required major courses listed below. The remaining 79 credit hours are for college and university requirements, general
electives, and additional mathematics courses that a student may wish to take.

Required Major Courses (42 credit hours)
Math 21, 22, 23 Calculus I, II, and III (12) or
Math 31, 32, 33 Honors Calculus I, II, III (12)
Math 205 Linear Methods (3)
Math 230 Ordinary Differential Equations (4)
Math 219 Principles of Analysis I (4)
Math 242 Linear Algebra (4)
Math 243 Algebra (4)
Math 220 Principles of Analysis II (4) or
Math 316 Complex Analysis (4) or
Math 208 Complex Variables (3)
Math Electives (12)

Electives (27 credit hours) These are to be selected to include a field of application with the approval of the faculty advisor.

B.S. in Mathematics

There are two programs that lead to the degree of bachelor of science in mathematics: a general mathematics option and an applied mathematics option. The former is recommended for students who wish to pursue mathematics in combination with a related field (such as physics, computer science or economics). The latter provides a broad background in the major areas of applicable mathematics. A student participating in the program is enrolled in the mathematics department. The programs involve a total of 121 credit hours, and each is divided into four parts. A student must achieve an average of 2.0 or higher in major courses.

General Mathematics Option
College and university requirements (37 credit hours)

Required Major Courses (39 credit hours)
Math 21, 22, 23 Calculus (12) or
Math 31, 32, 33 Honors Calculus I, II, III (12)
Math 12 Basic Statistics (4)
Math 231 Probability and Statistics (3)
Math 205 Linear Methods (3)
Math 219 Principles of Analysis I (4)
Math 208 Complex Variables (3) or
Math 316 Complex Analysis (4) or
Math 220 Principles of Analysis II (4) or
Math 242 Linear Algebra (4)
Math 243 Algebra (4)
Math Electives (12)
two CSc courses or one Csc course and Eng 1.

Major Electives (12 credit hours) Three courses with specific mathematical content chosen with the approval of the faculty advisor.

Electives (33 credit hours) These are to be selected with the approval of the faculty advisor to include at least 15 credit hours from at least two fields of application.

Applied Mathematics Option
College and university requirements (37 credit hours). See Section III.

Required Major Courses (45 credit hours)
Math 21, 22, 23 Calculus (12) or
Math 31, 32, 33 Honors Calculus (12)
Math 12 Basic Statistics (4) or
Math 231 Probability and Statistics (3)
Math 205 Linear Methods (3)
Math 208 Complex Variables (3) or
Math 316 Complex Analysis (4)
Math 219 Principles of Analysis I (4)
Math 230 Ordinary Differential Equations (4)
Math 242 Linear Algebra (4)
Math 261 Discrete Structures (3) or
Math 243 Algebra (4) or
Math 219 Principles of Analysis II (4)
Math 316 Complex Analysis (4)
Math 205 Linear Methods (3)
Math 208 Complex Variables (3) or
Math 316 Complex Analysis (4)
Math 219 Principles of Analysis I (4)
Math 230 Ordinary Differential Equations (4)
Math 242 Linear Algebra (4)
Math 261 Discrete Structures (3) or
Math 243 Algebra (4) or
Math 219 Principles of Analysis II (4)
Math 316 Complex Analysis (4)
Math 205 Linear Methods (3)
Math 208 Complex Variables (3) or
Math 316 Complex Analysis (4)
Math 219 Principles of Analysis I (4)
Math 230 Ordinary Differential Equations (4)
Math 242 Linear Algebra (4)
Math 261 Discrete Structures (3) or
Math 243 Algebra (4) or
Math 219 Principles of Analysis II (4)
Math 316 Complex Analysis (4)
Math 205 Linear Methods (3)
Math 208 Complex Variables (3) or
Math 316 Complex Analysis (4)

Major Electives (12 credit hours) Three courses with specific mathematical content chosen with the approval of the faculty advisor.

B.S. in Statistics
Statistics is concerned with the development and application of techniques for collecting, analyzing and interpreting data in such a way that the reliability of the conclusions can be quantified. Statistical analysis thus forms a fundamental tool in all experimental sciences and is important in understanding chance phenomena. Mathematical principles, especially probability theory, underlie all statistical analyses.

The program involves a total of 121 credit hours, which are divided into four parts.

College and university requirements (37 credit hours) section III.

Required Major Courses (42 credit hours)
Math 21, 22, 23 Calculus I, II, III (12) or
Math 31, 32, 33 Honors Calculus I, II, III (12)
Math 12 Basic Statistics (4)
Math 205 Linear Methods (3)
Math 309 Theory of Probability (3)
Math 310 Probability and Its Applications (3)
Math 312 Computational Statistics (3)
Math 334 Mathematical Statistics (4)
Math 338 Regression Analysis (4)
Math 374 Project (3)
two CSc courses or one Csc course and Eng 1.

Note: Math 12 may be replaced by Math 231. A student must achieve an average of 2.0 or higher in major courses.

Major Electives (12 credit hours) At least three courses with specific mathematical and statistical content chosen with the approval of the faculty advisor.

Elective (30 credit hours) These are to be selected from at least two fields of application of statistics and probability, such as biology, psychology, social relations, computer science, engineering, economics, and management.

Departmental Honors
Students may earn departmental honors by writing a thesis during their senior year. Students are accepted into the program during their junior year by the department chairperson. This acceptance is based upon the student's grades and a thesis proposal, which the student must prepare in conjunction with a thesis advisor selected by the student. An oral presentation as well as a written thesis are required for completion of the program.

Minor Programs
The department offers five minor programs in different branches of the mathematical sciences. The minors are designed...
to provide recognition to those students who take a program of study in mathematics or a related area in addition to their major requirements in the engineering, arts and science or business curricula. Each program requires four courses shown below, and Math 23 or 33. For substitutions, the student should consult the chairperson.

**Minor in Pure Mathematics**
Math 219, 242, 243
Math 220 or 303 or 307 or 316 or 342

**Minor in Applied Mathematics**
Two of Math 205, 208, 230, 231, 242, 320, 323
Math 322
Math 341

**Minor in Probability and Statistics**
Math 12 or 231
Math 309
Two of Math 310, 312, 334, 338

**Minor in Actuarial Science**
Math 202, 205, 230, 231
Math 309 or 334
For information on examinations of actuarial societies, students may consult their minor advisor.

**Minor in Astronomy**
Phy 21, Astr 2
Astr 211 and / or 221
Astr 332 and / or 342
Plus four courses selected from among the following: any Astronomy course except Astr 1, Csc 17, Math 208, 231, Phy 31, 213, 215, 348, 362

**Undergraduate Courses**

**Math 0. Preparation for Calculus** (2) summer-fall
Intensive review of fundamental concepts in mathematics utilized in calculus, including functions and graphs, exponentials and logarithms, and trigonometry. This course is for students who need to take Math 51 or 21, who require remediation in precalculus. In particular, students who fail the Math 51 Readiness Exam must pass Math 0 before being admitted to Math 51. The credits for this course do not count toward graduation, but do count on the GPA and current credit count. Prerequisite: department permission.

**Math 5. Introduction to Mathematical Thought** (3) spring
Meaning, content, and methods of mathematical thought illustrated by topics that may be chosen from number theory, abstract algebra, combinatorics, finite or non-Euclidean geometries, game theory, mathematical logic, set theory, topology. (MA)

**Math 9. Introduction to Finite Mathematics** (4) fall
Systems of linear equations, matrices, introduction to linear programming. Sets, counting methods, probability, random variables, introduction to Markov chains. Students may not receive credit for both Math 9 & 61. (MA)

**Math 12. Basic Statistics** (4) fall-spring
A first course in the basic concepts and methods of statistics with illustrations from the social, behavioral, and biological sciences. Descriptive statistics; frequency distributions, mean and standard deviation, two-way tables, correlation and regression; random sampling, rules of probability, probability distributions and parameters, parameter estimation, confidence intervals, hypothesis testing, statistical significance. (MA).

**Math 21. Calculus I** (4) fall-spring
Functions and graphs; limits and continuity; derivative, differential, and applications; Taylor's Theorem and other approximations; indefinite and definite integrals; trigonometric, logarithmic, exponential, and hyperbolic functions. (MA)

**Math 22. Calculus II** (4) fall-spring
Applications of integration; techniques of integration; separable differential equations, infinite sequences and series; curves and vectors in the plane. Prerequisite: Math 21 or Math 31. (MA)

**Math 23. Calculus III** (4) fall-spring
Vectors in space; partial derivatives; Lagrange multipliers; multiple integrals; vector analysis; exact differential equations and second-order differential equations with constant coefficients. Prerequisite: Math 22 or Math 32. (MA)

**Math 31. Honors Calculus I** (4) fall
Same topics as in Math 21, but taught from a more thorough and rigorous point of view. (MA)

**Math 32. Honors Calculus II** (4) fall-spring
Same topics as in Math 22, but taught from a more thorough and rigorous point of view. Prerequisite: Math 31. (MA)

**Math 33. Honors Calculus III** (4) fall-spring
Same topics as in Math 23, but taught from a more thorough and rigorous point of view. Prerequisite: Math 32. (MA)

**Math 43. Survey of Linear Algebra** (3) fall
Matrices, vectors, vector spaces and mathematical systems, special kinds of matrices, elementary matrix transformations, systems of linear equations, convex sets, introduction to linear programming. (MA). Students may not receive credit for both Math 61 & 43.

**Math 51. Survey of Calculus I** (4) fall-spring
Limits. The derivative and applications to extrema, approximation, and related rates. Exponential and logarithm functions, growth and decay. Integration. Partial derivatives and extrema. Prerequisite: Passing score on Readiness Exam, or Math 0. (MA)

**Math 52. Survey of Calculus II** (3) fall-spring
Trigonometric functions and related derivatives and integrals. Techniques of integration. Differential equations. Probability and calculus. Prerequisite: Math 21 or 31 or 51. (MA)

**Math 61. Linear Algebra for Business and Economics** (2) fall-spring
Matrices, solutions of linear systems, linear programming, examples from business and economics, computer solutions. (MA). Students may not receive credit for both Math 61 & 9, or for both Math 61 & 43.

**Math 75. Calculus I, Part A** (2) fall
Covers the same material as the first half of Math 21. Meets three hours per week, allowing more class time for each topic than does Math 21. (MA)

**Math 76. Calculus I, Part B** (2) spring
Continuation of Math 75, covering the second half of Math 21. Meets three hours per week. Final exam for this course is identical to the Math 21 final. Prerequisite: Math 75. (MA)

**Math 171. Readings** (1-3) fall-spring
Study of a topic in mathematics under individual supervision. Intended for students with specific interests in areas not covered in the listed courses. Prerequisite: consent of the department chair. (MA)
For Advanced Undergraduates and Graduate Students

Courses listed as (3-4) are 3 credits for graduate students and 4 credits for undergraduates. The extra credit will frequently involve some extra workshops or projects.

Math 201. Problem Solving (1) fall
Practice in solving problems from mathematical contests using a variety of elementary techniques. (MA)

Math 202. Actuarial Tests I and II (1) spring
Practice in solving problems from the first two actuarial exams; problems in calculus, linear algebra, probability and statistics. Prerequisite: Math 23. (MA)

Math 205. Linear Methods (3) fall-spring
Linear differential equations and applications; matrices and systems of linear equations; vector spaces; eigenvalues and application to linear systems of differential equations. Prerequisite: Math 23 or 52; 23 or 53 may be taken concurrently. (MA)

Math 207. (ChE 207) Introduction to Biomedical Engineering and Mathematical Physiology (3) fall
Topics in human physiology and mathematical analysis of physiological phenomena, including the cardiovascular and respiratory systems, biomechanics, and renal physiology; broad survey of bioengineering. Independent study projects. Prerequisite: Math 205. (MA)

Math 208. Complex Variables (3) fall-spring
Functions of a complex variable; calculus of residues; contour integration; applications to conformal mapping and Laplace transforms. Prerequisite: Math 23 or Math 33. (MA)

Math 219. Principles of Analysis I (3-4) fall
Existence of limits, continuity and uniform continuity; Heine-Borel Theorem; existence of extreme values; mean value theorem and applications; conditions for existence of the Riemann integral; absolute and uniform convergence; emphasis on theoretical material from the calculus of one variable. Prerequisite: Math 23 or Math 33. (MA)

Math 220. Principles of Analysis II (3-4) spring
Continuation of Math 219. Functions of several variables; line and surface integrals; implicit functions. Prerequisite: Math 219. (MA)

Math 230. Numerical Methods (3) fall
Representation of numbers and rounding error; numerical solution of equations; quadrature; polynomial and spline interpolation; numerical solution of initial and boundary value problems. Prerequisites: Math 205 (previously or concurrently) and knowledge of either FORTRAN or PASCAL. (MA)

Math 231. Probability and Statistics (3) fall-spring
Probability and distribution of random variables; populations and random sampling; chi-square, t, and F distributions; estimation and tests of hypotheses; correlation and regression theory of two variables. Prerequisite: Math 23 or Math 33 or Math 52. (MA)

Math 234. Fractal geometry (3-4)
Metric spaces and iterated function systems; various types of fractal dimension; Julia and Mandelbrot sets. Other topics such as chaos may be included. Small amount of computer use. Prerequisite: Math 23 or Math 33. (MA)

Math 242. Linear Algebra (3-4) fall
Thorough treatment of the solution of \( m \) simultaneous linear equations in \( n \) unknowns, including a discussion of the computational complexity of the calculation. Vector spaces, linear dependence, bases, orthogonality, eigenvalues. Application as time permits. Prerequisite: Math 23 or 33 or 52. (MA)

Math 243. Algebra (3-4) spring
Introduction to basic concepts of modern algebra: groups, rings, and fields. (MA)

Math 251. Combinatorics (3-4)
Topics selected from enumeration, graphs and networks, Ramsey theory, ordered sets, min-max duality, and designs. Theory will be motivated by applications from operations research and computer science. Prerequisite: Math 22 or consent of instructor. (MA)

Math 261. (Csc 261) Discrete Structures (3)
Topics in discrete mathematical structures chosen for their applicability to computer science and engineering. Sets, propositions, induction, recursion; combinatorics; binary relations and functions; ordering, lattices and Boolean algebra; graphs and trees; groups and homomorphisms. Prerequisites: Math 21, and either CSc 11 or Engr 1. (MA)

Math 303. (Phil 303) Mathematical Logic (3-4) fall
A course, on a mathematically mature level, designed not only to acquaint the student with logical techniques used in mathematics but also to present symbolic logic as an important adjunct to the study of the foundations of mathematics. Prerequisite: non-Math majors need Phil 114. (MA)

Math 304. Axiomatic Set Theory (3-4) fall
A development of set theory from axioms; relations and functions; ordinal and cardinal arithmetic; recursion theorem; axiom of choice; independence questions. Prerequisite: Math 219 or consent of the department chair. (MA)

Math 307. General Topology I (3-4) fall
An introductory study of topological spaces, including metric spaces, separation and countability axioms, connectedness, compactness, product spaces, quotient spaces, function spaces. Prerequisite: Math 219. (MA)

Math 309. Theory of Probability (3) fall
Probabilities of events on discrete and continuous sample spaces; random variables and probability distributions; expectations; transformations; simplest kind of law of large numbers and central limit theorem. The theory is applied to problems in physical and biological sciences. Prerequisite: Math 23 or Math 33 or Math 52. (MA)

Math 310. Probability and Its Applications (3-4) spring
Continuation of Math 309. Random variables, characteristic functions, limit theorems; stochastic processes, Kolmogorov equations; Markov chains, random walks. Prerequisite: Math 309 or consent of the department chair. (MA)

Math 312. Computational Statistics (3-4)
Exploratory data analysis; Monte Carlo methods; randomization and resampling. Computational aspects based on software tools and statistical packages. Prerequisite: Math 12 or Math 231. (MA)

Math 316. Complex Analysis (3-4) spring
Concept of analytic function from the points of view of the Cauchy-Riemann equations, power series, complex integration, and conformal mapping. Prerequisite: Math 219. (MA)

Math 320. Ordinary Differential Equations (3-4) spring
The analytical and geometric theory of ordinary differential equations, including such topics as linear systems, systems in the complex plane, oscillation theory, stability theory, geometric theory of nonlinear systems, finite difference methods, general dynamical systems. Prerequisite: Math 205, or both Math 23, 33 and Math 242. (MA)
Math 322. Methods of Applied Analysis I (3) fall
Fourier series, eigenfunction expansions, Sturm-Liouville problems, Fourier integrals and their application to partial differential equations; special functions. Emphasis is on a wide variety of formal applications rather than logical development. Prerequisite: Math 205 or consent of the department chair. (MA)

Math 323. Methods of Applied Analysis II (3) spring
Green's functions; integral equations; variational methods; asymptotic expansions, method of saddle points; calculus of vector fields, exterior differential calculus. Prerequisite: Math 243 or consent of the department chair. (MA)

Math 327. Groups and Rings (3-4) fall
An intensive study of the concepts of group theory including the Sylow theorems, and of ring theory including unique factorization domains and polynomial rings. Prerequisite: Math 322. (MA)

Math 329. Recursive Functions and the Theory of Computation (3-4) spring
Core development of classical recursion theory, enumeration, index and recursion theorems, using a simple programming language as a model of computation. Other models of computation and Church's Thesis. Recursive operators and their fixed points. (MA)

Math 334. Mathematical Statistics (3-4) spring
Populations and random sampling; sampling distributions; theory of statistical estimation; criteria and methods of point and interval estimation; theory of testing statistical hypotheses. Prerequisite: Math 231 or Math 309. (MA)

Math 338. Regression Analysis (3-4) spring
Least square principles in multiple regression and their interpretations; estimation, hypothesis testing, confidence and prediction intervals; residual analysis, multicollinearity, selection of regression models; comparison of data sets; analysis of variance and covariance; simultaneous inference procedures. Use of computer packages for statistical analysis. Prerequisite: Math 12 or 231. (MA)

Math 340. (CSc 340) Design and Analysis of Algorithms (3) spring
Algorithms for searching, sorting, counting, graph and tree manipulation, matrix multiplication, scheduling, pattern matching and fast Fourier transforms. Abstract complexity measures and the intrinsic complexity of algorithms and problems in terms of asymptotic behavior; correctness of algorithms. Prerequisites: Math 22 and CSc 261, or consent of the department chairperson. (MA)

Math 341. Mathematical Models and Their Formulation (3) spring
Mathematical modeling of engineering and physical systems with examples drawn from diverse disciplines such as traffic flow, laser drilling, mold solidification, rocket design and business planning. Prerequisite: Math 305. (MA)

Math 342. Number Theory (3-4)
A survey of elementary and nonelementary algebraic and analytic methods in the theory of numbers. Includes the Euclidean algorithm, Diophantine equations congruences, quadratic residues, primitive roots, number-theoretic functions as well as one or more of the following topics: distribution of primes, Pell's equation, Fermat's theorem, partitions. Prerequisite: Math 205 or consent of the department chair. (MA)

Math 350. Special Topics (3) fall-spring
A course covering special topics not sufficiently covered in listed courses. Prerequisite: consent of the department chair. May be repeated for credit. (MA)

Math 371. Readings (1-3) fall-spring
The study of a topic in mathematics under appropriate supervision, designed for the individual student who has studied extensively and whose interests lie in areas not covered in the listed courses. Prerequisite: consent of the department chair. May be repeated for credit. (MA)

Math 374. Statistical Project (3)
Supervised field project or independent reading in statistics or probability. Prerequisite: consent of the department chair. (MA)

Math 391. Senior Honors Thesis (3) fall-spring
Independent research under faculty supervision, culminating in a thesis presented for departmental honors. May be repeated once for credit. Prerequisite: consent of chair. (MA)

Graduate Programs in Mathematics
The department offers graduate programs leading to the degrees of master of science in mathematics, applied mathematics, or statistics, and the doctor of philosophy in mathematics or applied mathematics.

To begin graduate work in mathematics a student must present evidence of adequate undergraduate preparation. The undergraduate program should have included a year of advanced calculus, a semester of linear algebra, and a semester of abstract algebra.

M.S. in Mathematics or Applied Mathematics
The master's program demands 30 credit hours of graduate courses with at least 18 hours at the 400 level. With the permission of the chairperson, up to six hours of these courses can be replaced by a thesis. All students in the master's program must also pass a comprehensive examination. The M.S. degree can serve both as a final degree in mathematics or as an appropriate background for the Ph.D. degree.

M.S. in Statistics
This program requires 30 credit hours of graduate courses with at least 18 hours of 400-level Stat or Math courses. The choice of courses must be approved by the graduate advisor, and up to six hours of coursework may be replaced with a thesis. All students in the program must also pass a comprehensive examination.


Ph.D. in Mathematics
The plan of work toward the doctor of philosophy degree will include a comprehensive examination and a qualifying examination. The latter tests the student's command of three of the following areas: analysis, functional analysis, algebra, combinatorial theory, geometry, topology, probability, statistics, logic, numerical analysis, and differential equations. A general examination, a foreign language examination, and the doctoral dissertation and its defense complete the work for the Ph.D. degree.

The department accepts candidates for the Ph.D. who desire to specialize in any of the areas listed above. Each candidate's plan of work must be approved by a special committee of the department. Although there are no specific course requirements, the Ph.D. candidates normally take several courses related to their area of specialization.
Ph.D. in Applied Mathematics

In this program, the three qualifying examinations are chosen from among applied probability; differential equations; discrete structures, combinatorial analysis and graph theory; linear algebra and linear programming; numerical methods; or another area in the mathematical and physical sciences chosen by the applicant and approved by the department. Aside from this, the program description agrees with the above description of the Ph.D. in mathematics.

Graduate Courses

Math 401. Real Analysis I (3) fall
Set theory, real numbers; introduction to measures, Lebesgue measure; integration, general convergence theorems; differentiation, functions of bounded variation, absolute continuity; Lp spaces. Prerequisites: Math 220 or consent of the department chair.

Math 402. Real Analysis II (3) spring
Metric spaces; introduction to Banach and Hilbert space theory; Fourier series and Fejer operators; general measure and integration theory, Radon-Nikodym and Riesz representation theorems; Lebesgue-Stieljtes integral. Prerequisites: Math 307 and Math 401.

Math 404. Mathematical Logic (3)
Topics in quantification theory relevant to formalized theories, recursive functions, Godel's incompleteness theorem; algorithms and computability.

Math 405. Partial Differential Equations I (3) fall
Classification of partial differential equations; methods of characteristics for first order equations; methods for representing solutions of the potential, heat, and wave equations, and properties of the solutions of these equations; maximum principles. Prerequisite: Math 220 or its equivalent.

Math 406. Partial Differential Equations II (3) spring
Continuation of Math 405. Emphasis on second order equations with variable coefficients and systems of first order partial differential equations. Prerequisite: Math 405.

Math 407. Theory and Technique of Optimization (3)
Linear programming: simplex and revised simplex methods, duality theory; unconstrained optimization by one-dimensional search methods; convexity and Kuhn-Tucker conditions, applications to methods for constrained optimization.

Math 408. Algebraic Topology I (3)
Polyhedra; fundamental groups; simplicial and singular homology.

Math 409. (Stat 409) Mathematics Seminar (1-6) fall
An intensive study of some field of mathematics not offered in another course. Prerequisite: consent of the department chair.

Math 410. (Stat 408) Mathematics Seminar (1-6) spring
Continuation of the field of study in Math 409 or the intensive study of a different field. Prerequisite: consent of the department chair.

Math 414. Topics in Ordinary Differential Equations (3)
Topics from the analytical and qualitative theory of differential equations and dynamical systems such as: structural stability, ordered chaos and strange attractors, bifurcation theory, normal forms, asymptotic methods, spectral theory of differential operators, boundary value problems. Prerequisite: consent of the department chair.

Math 416. Complex Function Theory (3) fall
Continuation of Math 316. Prerequisite: Math 316 or consent of the department chair.

Math 419. Linear Operators on Hilbert Space (3)
Algebra and calculus of bounded and unbounded operators on Hilbert space; spectral analysis of self-adjoint, normal, and unitary operators. Interplay between operator theory and classical function theory is emphasized. Prerequisites: Math 220, and Math 208 or Math 316.

Math 421. Introduction to Wavelets (3)
Continuous and discrete signals; review of Fourier analysis; discrete wavelets; time-frequency spaces; Haar and Walsh systems; multiresolution analysis; Hilbert spaces; quadratic mirror filters; fast wavelet transforms; computer code; applications to filtering, compression, and imaging. Prerequisite: ECE 108, Math 205, or consent of instructor.

Math 422. Differential Geometry I (3)
Differential manifolds, tangent vectors and differentials, submanifolds and the implicit function theorem. Lie groups and Lie algebras, homogeneous spaces. Tensor and exterior algebras, tensor fields and differential forms, de Rham cohomology, Stokes's theorem, the Hodge theorem. Prerequisite: Math 219, 220, or Math 243 or Math 244 or Math 205 with consent of instructor.

Math 424. Differential Geometry II (3)
Curves and surfaces in Euclidean space; mean and Gaussian curvatures, covariant differentiation, parallelism, geodesics, Gauss-Bonnet formula. Riemannian metrics, connections, sectional curvature, generalized Gauss-Bonnet theorem. Further topics. Prerequisite: Math 423.

Math 428. Fields and Modules (3) spring
Field theory, including an introduction to Galois theory; the theory of modules, including tensor products and classical algebras. Prerequisite: Math 327.

Math 430. Numerical Analysis (3) spring
Multistep methods for ordinary differential equations; finite difference methods for partial differential equations; numerical approximation of functions. Use of computer required. Prerequisite: Math 230 or consent of the department chair.

Math 431. Calculus of Variations (3)
Existence of a relative minimum for single and multiple integral problems; variational inequalities of elliptic and parabolic types and methods of approximating a solution. Prerequisite: Math 220 or its equivalent.

Math 435. Functional Analysis I (3) fall
Banach spaces and linear operators; separation and extension theorems; open mapping and uniform boundedness principles; weak topologies; local convexity and duality; Banach algebras; spectral theory of operators; and compact operators. Prerequisites: Math 307 and Math 401.

Math 436. Functional Analysis II (3) spring
Continuation of Math 435. Topics such as distribution theory, nonlinear operators, fixed point theory and applications to classical analysis. Prerequisite: Math 435.

Math 443. General Topology II (3)
Continuation of Math 307, with such topics as filters and nets, topological products, local compactness, paracompactness, metrizability, uniformity, function spaces, dimension theory. Prerequisite: Math 307.

Math 444. Algebraic Topology II (3)
Continuation of Math 408. Cohomology theory, products, duality. Prerequisite: Math 408.
Arbitrage Pricing Theory in the context of the binomial model and Black-Sholes model. Option pricing in more realistic scenarios. Introduction to the theory of Brownian motion and Itô calculus. Prerequisites: Math 23, 43, or 205, 12 or 231, or consent of instructor.

Math 468. Financial Calculus II (3) spring
Topics on continuous-time martingales, Brownian motion and Itô calculus. The absence of arbitrage opportunities and the existence of equivalent martingale measures. The pricing of contingent claims. Quantitative methods for portfolio management with the Capital Asset Pricing Model and Merton's continuous time dynamic models. Models for the random evolution of the term structure of interest rates. Prerequisites: Math 402, or Math 463 and 467, or consent of instructor.

Math 470. Proseminar (3) spring
Preparation for entering the mathematics profession. Seminar will concentrate on methods of teaching mathematics, and will include other topics such as duties of a professor and searching for a job. Prerequisite: consent of mathematics graduate advisor.

Math 471. Homological Algebra (3)
Modules, tensor products, categories and functions, homology functors, projective and injective modules. Prerequisite: Math 428.

Math 472. Group Representations (3)
Linear representations and character theory with emphasis on the finite and compact cases. Prerequisite: Math 428 or consent of the department chairperson.

Math 490. Thesis
Math 499. Dissertation

Statistics

Stat 408. (Math 410) Seminar in Statistics and Probability (1-6) spring
Intensive study of some field of statistics or probability not offered in another course. Prerequisite: consent of the graduate advisor.

Stat 409 (Math 409) Seminar in Statistics and Probability (1-6) fall
Intensive study of some field of statistics or probability not offered in another course. Prerequisite: consent of the graduate advisor.

Stat 410. Probability and its Applications (3) spring
See Math 310.

Stat 412. Computational Statistics (3)
See Math 312.

Stat 434. Mathematical Statistics (3) spring
See Math 334.

Stat 438. Regression Analysis (3) spring
See Math 338


Mechanical Engineering and Mechanics

Professors. Charles R. Smith, Ph.D. (Stanford), chair; Philip A. Blythe, Ph.D. (Manchester, England); Forbes T. Brown, Sc.D. (M.I.T.); Terry J. Delph, Ph.D. (Stanford); Fazil Erdogan, Ph.D. (Lehigh); C. Whitney Snyder Professor; D. Gary Harlow, Ph.D. (Cornell), Ronald J. Harkin, Ph.D. (Lehigh); Stanley H. Johnson, Ph.D. (Berkeley); Arturs Kalnins, Ph.D. (Michigan); Jacob Y. Kazakia, Ph.D. (Lehigh); Edward K. Levy, Sc.D. (M.I.T.), director, Energy Research Center; Antonios Liakopoulos, Ph.D. (Florida); Alistair K. Macpherson, Ph.D. (Sydney, Australia); Sudhakar Neti, Ph.D. (Kentucky); Herman F. Nied, Ph.D. (Lehigh); John Ochs, Ph.D. (Penn State); Tulga M. Ozsoy, Ph.D. (Istanbul, Turkey); Richard Roberts, Ph.D. (Lehigh); Donald O. Rockwell, Ph.D. (Lehigh); Paul B. Reinhold Professor; Kenneth N. Sawyers, Ph.D. (Brown); Eric Varley, Ph.D. (Brown); Arkady Voloship, Ph.D. (Tel-Aviv, Israel); J. David A. Walker, Ph.D. (Western Ontario, Canada); Robert P. Wei, Ph.D. (Princeton), Paul B. Reinhold Professor.

Associate professors. Meng-Sang Chew, Ph.D. (Columbia); John P. Coulter, Ph.D. (Delaware); Robert A. Lucas, Ph.D. (Lehigh), associate chair; N. Duke Perreira, Ph.D. (California, Los Angeles).

Assistant professor. Alparslan Öztekin, Ph.D. (Illinois)

Educational Mission

The Department of Mechanical Engineering and Mechanics prepares our students to be life-long learners, and more importantly, to be leaders and agents in both the application and development of technology to better serve the needs of society.

Engineering is a creative profession aimed at satisfying needs of society through the combination of material, human and economic resources. The programs in mechanical engineering and in engineering mechanics are designed so that students will be ready upon graduation to pursue satisfying and productive careers in a wide variety of fields. Separate degree programs are offered leading to the degrees of bachelor of science in mechanical engineering or bachelor of science in engineering mechanics.

Graduates with either degree are equipped for work in engineering, research and development, government service or industry. Those with ability and interest have the necessary background to pursue further studies at the graduate level.

Because of the flexibility of the curriculum, candidates for either degree may combine the study of mechanical engineering or engineering mechanics with that of other fields, such as business, industrial engineering, chemical engineering, electrical engineering, materials engineering and biology. The resulting interdisciplinary programs prepare students for work in areas such as manufacturing, engineering management, systems design, nuclear engineering, energy conversion and conservation, environmental engineering, materials engineering or biomechanics.

Undergraduates become thoroughly familiar with Lehigh's computer-aided design (CAD) laboratory. This laboratory is a teaching facility where students learn a set engineering tools that can be applied to solve a wide variety of problems.

B.S. in Mechanical Engineering

Mechanical engineering is one of the broadest of the engineering professions, dealing generally with systems for energy conversion, material transport and the control of motions and forces.

Mechanical engineers may choose from among many different activities in their careers, according to their interests and the changing needs of society. Some concentrate on the conversion of thermal, nuclear, solar, chemical and electrical energy, or on the problems of air, water, and noise pollution. Some concentrate on the design of mechanical systems used in transportation, manufacturing or health care industries or by individual consumers. Some will be working, a decade from now, in fields that do not yet exist. Most will be engaged with concepts involving all four dimensions of space and time.

The curriculum leading toward the bachelor of science in mechanical engineering combines a broad base in mathematics, physical sciences, and the engineering sciences (mechanics of solids, materials, dynamics and fluid, thermal and electrical sciences), including laboratory. Special emphasis is placed on the practice of modern Integrated Product Development, combining state-of-the-art computer-aided design and manufacturing methods in a business-oriented framework. Several specific application fields are chosen toward the end of the program in the form of four or more courses elected from a wide variety of 300-level offerings. Courses in mechanical engineering and engineering mechanics are equally available.

The course requirements for a B.S. degree in mechanical engineering are listed below. In addition to required mathematics, physics, chemistry and basic engineering courses, the program includes a minimum of seven courses in humanities and social sciences (see humanities/social sciences), two free electives and five approved electives. The total graduation requirement is 131 credits.

Undergraduate Curriculum in Mechanical Engineering

Freshman Year (see Engineering, freshman year, Section III)

Sophomore Year, First Semester (16 - 18 credit hours)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 10</td>
<td>Graphics for Engineering Design</td>
<td>3</td>
</tr>
<tr>
<td>ME 111</td>
<td>Professional Development</td>
<td>1</td>
</tr>
<tr>
<td>Mech 2</td>
<td>Elementary Engineering Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>Mat 33</td>
<td>Engineering Materials and Processes</td>
<td>3</td>
</tr>
<tr>
<td>Math 23</td>
<td>Analytical Geometry &amp; Calculus III</td>
<td>4</td>
</tr>
</tbody>
</table>

Sophomore Year, Second Semester (16 - 18 credit hours)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 104</td>
<td>Thermodynamics I</td>
<td>3</td>
</tr>
<tr>
<td>Mech 12</td>
<td>Strength of Materials</td>
<td>3</td>
</tr>
<tr>
<td>Phy 21,22</td>
<td>Introductory Physics II and Laboratory</td>
<td>5</td>
</tr>
<tr>
<td>Math 205</td>
<td>Linear Methods</td>
<td>3</td>
</tr>
</tbody>
</table>

Junior Year, First Semester (16 - 18 credit hours)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 21</td>
<td>Mechanical Engineering Lab I</td>
<td>1</td>
</tr>
<tr>
<td>ME 231</td>
<td>Fluid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>Mech 102</td>
<td>Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>ECE 81</td>
<td>Principles of Electrical Engineering</td>
<td>4</td>
</tr>
<tr>
<td>Math 208</td>
<td>Complex Variables</td>
<td>3</td>
</tr>
<tr>
<td>Mat 230</td>
<td>Numerical Methods</td>
<td>3</td>
</tr>
<tr>
<td>Math 231</td>
<td>Probability and Statistics</td>
<td>3</td>
</tr>
</tbody>
</table>

Junior Year, Second Semester (16 - 18 credit hours)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 121</td>
<td>Mechanical Engineering Lab II</td>
<td>1</td>
</tr>
<tr>
<td>ME 211</td>
<td>Mechanical Engineering Design</td>
<td>3</td>
</tr>
<tr>
<td>ME 240</td>
<td>Manufacturing</td>
<td>3</td>
</tr>
<tr>
<td>ME 242</td>
<td>Mechanical Engineering Systems</td>
<td>3</td>
</tr>
<tr>
<td>ME 252</td>
<td>Mechanical Elements</td>
<td>3</td>
</tr>
<tr>
<td>ECE 162</td>
<td>Electrical Laboratory</td>
<td>1</td>
</tr>
</tbody>
</table>

Senior Year, First Semester (16 - 18 credit hours)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 207</td>
<td>Mechanical Engineering Lab III</td>
<td>2</td>
</tr>
<tr>
<td>ME 212</td>
<td>Mechanical Engineering Design II</td>
<td>2</td>
</tr>
</tbody>
</table>

Senior Year, Second Semester (16 - 18 credit hours)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 208</td>
<td>Mechanical Engineering Lab IV</td>
<td>2</td>
</tr>
<tr>
<td>ME 210</td>
<td>Laboratory Projects</td>
<td>2</td>
</tr>
</tbody>
</table>

The courses listed above are subject to change with the approval of the Department of Mechanical Engineering and Mechanics.
The total number of credits required for graduation is 131. A total of 41 credits in electives must be taken. These electives are of six types:

(a) (17) Humanities/Social Sciences: A total of 17 credits of electives in humanities and social science which must include Eco 1. (Note that these electives are in addition to the 6 hours of required freshman English.) See description of HSS in Section III

(b) (6) Free electives: 6 credit hours in any subject area are required

(c) (3) ME 321 Introduction to Heat Transfer (3)
(d) (3) Engr. Elective A: One, 3-credit course selected from the following: Mech 302, Mech 305, ME 304, ME 322, ME 331, or ME 343
(e) (3) Engr. Elective B: One, 3-credit course selected from any ME 300 or Mech 300-level course
(f) (9) Engr. Elective C: Three, 3-credit courses selected from any ME 300/Mech 300-level course or an engineering/science/mathematics course, as approved by the department chair

B.S. in Engineering Mechanics
The curriculum in engineering mechanics is designed to prepare students for careers in engineering research and development, and is especially appropriate for students wishing to specialize in the analysis of engineering systems. In many industries and governmental laboratories there is a demand for men and women with broad training in the fundamentals of engineering in which engineering mechanics and applied mathematics play an important part.

The first two years of the curriculum is the same as that in mechanical engineering. One of the advantages of the curriculum is the flexibility it offers through 18 credits of technical and six credits of personal electives in the junior and senior years. Beyond the sophomore year there is required courses in dynamics, solid mechanics, fluid mechanics, heat transfer, principles of electrical engineering, mathematics, vibrations, and senior laboratories or projects. It is recommended that the electives be chosen to concentrate in areas such as applied mathematics and computational mechanics, solid mechanics, engineering materials, and fluid mechanics or to obtain further depth in all areas. The academic advisor for the engineering mechanics program will provide guidance in formulating the student’s goals and choosing electives.

In addition to the required and elective courses in mathematics, sciences, and engineering, the B.S. degree program in engineering mechanics includes a minimum of seven courses in humanities and social sciences (see humanities/social sciences). The total graduation requirement is 133 credits.

Undergraduate Curriculum in Engineering Mechanics

**freshman and sophomore years: same as ME curriculum**

**junior year, first semester (16 - 18 credit hours)**
- ME 21 Mechanical Engineering Lab I (1)
- ME 231 Fluid Mechanics (3)
- Mech 102 Dynamics (3)
- ECE 81 Principles of Electrical Engineering (4)
- Math 230 Numerical Methods (3) elective (2 - 4)

**junior year, second semester (16 - 18 credit hours)**
- ME 121 Mechanical Engineering Lab II (1)
- ME 240 Manufacturing (3)
- ME 242 Mechanical Engineering Systems (3)
- ECE 162 Electrical Laboratory (1)
- Math 208 Complex Variables (3) electives (5 - 7)

**senior year, first semester (16 - 18 credit hours)**
- ME 207 Mechanical Engineering Lab III (2) electives (14 - 16)

**senior year, second semester (16 - 18 credit hours)**
- ME 208 Mechanical Engineering Lab IV (2) or ME 210 Laboratory Projects (2) electives (14 - 16)

The total number of credits required for graduation is 133. A total of 44 credits in electives must be taken. These electives are of five types:

(a) (17) Humanities/Social Sciences: A total of 17 credits of electives in humanities and social science which must include Eco 1. (Note that these electives are in addition to the 6 hours of required freshman English.) See description of HSS in Section III

(b) (6) Free electives: 6 credit hours in any subject area are required

(c) (3) ME 321 Introduction to Heat Transfer (3)
(d) (6) Engr. Mechanics Elective A: Two, 3-credit courses selected from the following: Mech 302, Mech 305, ME 304, ME 322, ME 331, or ME 343
(e) (12) Engr. Mechanics Elective B: Four, 3-credit courses selected from any ME 300/Mech 300-level course or an engineering/science/mathematics course, as approved by the Department Chair

Typical recommended options:

**Applied Mathematics and Computational Mechanics**
- Mech 305 Advanced Mechanics of Materials (3)
- Mech 312 Finite Element Analysis (3)
- Math 309 Theory of Probability (3)
- Math 322 Methods of Applied Analysis I (3)
- Math 323 Methods of Applied Analysis II (3)

**Solid Mechanics**
- Mech 305 Advanced Mechanics of Materials (3)
- Mech 307 Mechanics of Continua (3)
- Mech 312 Finite Element Analysis (3)
- Mech 313 Fracture Mechanics (3)
- Math 322 Methods of Applied Analysis I (3)

**Engineering Materials**
- Mech 305 Advanced Mechanics of Materials (3)
- Mech 313 Fracture Mechanics (3)
- Mat 218 Mechanical Behavior of Materials (3)
- Phy 31 Introduction to Quantum Mechanics (3)
- Phy 363 Physics of Solids (3)

**Fluid Mechanics**
- ME 331 Advanced Fluid Mechanics (3)
- Mech 326 Aerodynamics (3)
- Math 322 Methods of Applied Analysis I (3)

**Undergraduate Courses in Mechanical Engineering**

**ME 10. Graphics for Engineering Design (3) fall**
Graphical description of mechanical engineering design for visualization and communication by freehand sketching, production drawings, and 3-D solid geometric representations. Introduction to creation, storage, and manipulation of such graphical descriptions through an integrated design project using state-of-the-art, commercially available computer-aided engineering software. Lectures and laboratory. (ESI), (ED2)

**ME 21. Mechanical Engineering Laboratory I (1) fall, spring**
Experimental methods in mechanical engineering and mechanics. Analysis of experimental error and error
propagation. Introduction to elementary instrumentation. Introduction to digital data acquisition. Prerequisite: Mech 12, previously or concurrently. (ES 1), (ED 0)

ME 104. Thermodynamics I (3) fall, spring
Basic concepts and principles of thermodynamics with emphasis on simple compressible substances. First and second law development, energy equations, reversibility, entropy and efficiency. Properties of pure substances and thermodynamic cycles. Corequisites: Math 23 and Phy 11. (ES 3), (ED 0)

ME 111. Professional Development (1) fall
Examination of ethical and professional choices facing mechanical engineers. Written and oral communications. Industrial field trips. (ES 0.5), (ED 0.5)

ME 121. Mechanical Engineering Laboratory II (1) fall, spring
A continuation of ME 21 including use of transducers, advanced instrumentation, and data acquisition. Emphasis on experimental exercises that illustrate, and/or introduce material from thermodynamics, and fluid mechanics. Includes proposal writing and interpretation of results. Prerequisites: ME 21, ME 104, and co-requisite: ME 231. (ES 1), (ED 0)

ME 207. Mechanical Engineering Laboratory III (2) fall
Formulation of laboratory experiments through open-ended planning, including decision criteria for laboratory techniques and approaches. Execution of experiments based on individual plans, followed by assessment of experimental results. Prerequisite: ME 121. (ES 1), (ED 1)

ME 208. Mechanical Engineering Laboratory IV (2) spring
Formulation of laboratory experiments through open-ended planning, including decision criteria for laboratory techniques and approaches. Execution of experiments based on individual plans, followed by assessment of experimental results. Prerequisite: ME 121. (ES 1), (ED 1)

ME 210. Laboratory Projects (1-2) fall, spring
Experimental work including planning, design, and development of apparatus, data collection and analysis as it pertains to an engineering problem. Progress is reported in the form of several planning and project reports. Prerequisite: Consent of department chair. (ES 1), (ED 1)

ME 211. Mechanical Engineering Design I (3) spring
Integrated Product Development (IPD) Capstone Course I. Industry-based design projects. Design methodology, feasibility study of design alternatives, engineering design analyses, integrated product development methodology, oral and written communications. Prerequisites: ME 10, Mech 12, ME 104. (ES 0), (ED 3)

ME 212. Mechanical Engineering Design II (2) fall
Integrated Product Development (IPD) Capstone Course II. Industry-based design projects continued from ME 211. Design analysis and simulation studies by student teams. Fabrication, assembly, and testing prototypes, production planning and simulation. Oral and written communications. Prerequisites: ME 211, ME 252 (ME 252 may be taken concurrently). (ES 0), (ED 2)

ME 231. Fluid Mechanics (3) fall, spring
Kinematics of fluid flow and similarity concepts. Equations of incompressible fluid flow with viscous and inviscid applications. Turbulence. One-dimensional compressible flow, shock waves. Boundary layers, separation, wakes and drag. Prerequisite: Math 205. (ES 3), (ED 0)

ME 240. Manufacturing (3) spring
Analytical and technological base for several manufacturing processes and common engineering materials. Processes include metal cutting, metal deformation, injection molding, thermoforming, and composites. Process planning, computer-aided manufacturing, manufacturing system engineering, and quality measurements. Design project. Weekly laboratory. Prerequisites: ME 10, Mat 33, Mech 12. (ES 1.5), (ED 1.5)

ME 242. Mechanical Engineering Systems (3) fall, spring
The modeling and analysis of mechanical, fluid, electrical and hybrid systems, with emphasis on lumped models and dynamic behavior, including vibrations. Source-load synthesis. Analysis in temporal and frequency domains. Computer simulation of nonlinear models, and computer implementation of the superposition property of linear models. Prerequisites: Mech 102, Math 205 and, previously or concurrently, ME 231. (ES 2), (ED 1)

ME 252. Mechanical Elements (3) fall, spring
Methods for the design of machine elements such as springs, gears, clutches, brakes, and bearings. Motion analysis of cams and selected mechanisms. Projects requiring the design of simple mechanisms of mechanical sub-assemblies. Prerequisites: Mech 12, ME 10 and Mech 102. (ES 1.5), (ED 1.5)

For Advanced Undergraduates and Graduate Students

ME 304. Thermodynamics II (3) fall, spring

ME 310. Directed Study (1-3) fall, spring
Project work on any aspect of engineering, performed either individually or as a member of a team made up of students, possibly from other disciplines. Project progress is reported in the form of several planning and project reports. Direction of the projects may be provided by faculty from several departments and could include interaction with outside consultants and local communities and industries. Prerequisite: consent of the department chair. (ES 1), (ED 2)

ME 312. Synthesis of Mechanisms (3) fall
Geometry and constrained plane motion with application to linkage design. Type of number synthesis. Comparison of motion analysis by graphical, analytical and computer techniques. Euler-Savary and related curvature techniques as applied to cam, gear and linkage systems. Introduction to the analysis of space mechanisms. Prerequisites: Math 205, Mech 102. Lucas. (ES 1), (ED 2)

ME 321. Introduction to Heat Transfer (3) fall, spring
Analytical and numerical solutions to steady and transient one- and two-dimensional conduction problems. Forced and natural convection in internal and external flows. Thermal design of engineering processes and systems. Prerequisites: ME 104, ME 231. Neti, Blythe, MacPherson. (ES 2), (ED 1)

ME 322. Gas Dynamics (3) spring

ME 323. Reciprocating and Centrifugal Engines (3) fall
Thermal analysis and design of internal combustion engines (conventional and unconventional), gas turbine engines, air
breathing jet engines, and rockets. Components such as jet nozzles, compressors, turbines, and combustion chambers are chosen to exemplify the theory and development of different types of components. Both ideal fluid and real fluid approaches are considered. Prerequisite: ME 104. (ES 2.5), (ED 0.5)

ME 331. Advanced Fluid Mechanics (3) fall

ME 340. Advanced Mechanical Design (3) fall
Probabilistic design of mechanical components and systems. Reliability functions, hazard models and product life prediction. Theoretical stress-strength-time models. Static and dynamic reliability models. Optimum design of mechanical systems for reliability objectives or constraints. Prerequisite: Math 231 or consent of instructor. Harlaw. (ES 2), (ED 1)

ME 341. Mechanical Systems (3) spring
Advanced topics in mechanical systems design. Kinematics and dynamics of planar machinery. Shock and vibration control in machine elements. Balancing of rotating and reciprocating machines. Design projects using commercial computer-aided-engineering software for the design and evaluation of typical machine systems. Prerequisite: ME 252. Lucas. (ES 1.5), (ED 1.5)

ME 342. Dynamics of Engineering Systems (3) spring
Dynamic analysis of mechanical, electro-mechanical, fluid and hybrid engineering systems with emphasis on the modeling process. Lumped and distributed-parameter models. Use of computer tools for modeling, design and simulation. Design projects. Prerequisite: ME 242. Brown. (ES 2), (ED 1)

ME 343. Control Systems (3) fall
Linear analyses of mechanical, hydraulic and electrical feedback control systems by root locus and frequency response techniques. A design project provides experience with practical issues and tradeoffs. Prerequisite: ME 242 or ECE 125. Johnson. (ES 2), (ED 1)

ME 345. Fluid Power (3)
Design, modeling and static and dynamic analyses of fluid power pumps, motors, valves, lines, and systems, with emphasis on developing a fundamental understanding of industrial and mobile hydraulics and hydraulic servosystems. Laboratory demonstrations and experiments; design projects. Prerequisites: ME 231 and ME 242. (ME 242 may be taken concurrently). Brown. (ES 1), (ED 2)

ME 348. Computer-Aided Design (3) spring
Impact of computer-aided engineering tools on mechanical design and analysis. Part geometry modeling and assembly modeling using solid representations. Analysis for mass properties, interference, kinematics, displacements, stresses and system dynamics by using state-of-the-art commercially available computer-aided-engineering software. Integrated design projects. Two-hour lectures and two-hour lab per week. Prerequisites: ME 10, ME 252, ME 242. Lucas, Ozzooy. (ES 1), (ED 2)

ME 350. Special Topics (1-4)
A study of some field of mechanical engineering not covered elsewhere. Prerequisite: consent of the department chair. (ES 1), (ED 2)

ME 360. (ChE 360) Nuclear Reactor Engineering (3) spring
A consideration of the engineering problems related to nuclear reactor design and operation. Topics include fundamental properties of atomic and nuclear radiation, reactor fuels and materials, reactor design and operation, thermal aspects, safety and shielding, instrumentation and control. Course includes several design projects stressing the major topics in the course. Prerequisite: Senior standing in engineering or physics science. Neit. (ES 2), (ED 1)

ME 387. (ChE 387, ECE 387) Digital Control (3) spring
Sampled-data systems; z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Lyapunov stability state feedback control (two lectures and one laboratory per week). Prerequisite: ChE 386 or ECE 212 or ME 343 or consent of instructor. Luyben. (ES 3), (ED 0)

ME 389. (ECE 389, ChE 389) Control Systems Laboratory (2) spring
Experiments on a variety of mechanical, electrical and chemical dynamic control systems. Exposure to state-of-the-art control instrumentation: sensors, transmitters, control valves, analog and digital controllers. Emphasis on design of feedback controllers and comparison of theoretical computer simulation predictions with actual experimental data. Lab teams will be interdisciplinary. Prerequisites: Either ChE 386, ME 343, or ECE 212. Johnson. (ES 1), (ED 1)

Undergraduate Courses in Engineering Mechanics

Mech 2. Elementary Engineering Mechanics (3) fall, spring
Static equilibrium of particles and rigid bodies. Analysis of simple truss and frame structures, internal forces, stress, strain, and Hooke’s Law; torsion of circular shafts; pure bending of beams. Prerequisites: Math 22 and Phys 11. (Math 22 may be taken concurrently). (ES 2.5), (ED 0.5)

Mech 12. Strength of Materials (3) fall, spring

Mech 102. Dynamics (3) fall, spring
Particle dynamics, work-energy, impulse-momentum, impact, systems of particles; kinematics of rigid bodies, kinematics of rigid bodies in plane motion, energy, momentum, eccentric impact. Prerequisites: Mech 2 and Math 23. (ES 3), (ED 0)

Mech 103. Principles of Mechanics (4)
Composition and resolution of forces; equivalent force systems; equilibrium of particles and rigid bodies; friction. Kinematics and kinetics of particles and rigid bodies; relative motion; work and energy; impulse and momentum. Prerequisites: Math 23 and Phys 11. (ES 4), (ED 0)

For Advanced Undergraduates and Graduate Students

Mech 302. Advanced Dynamics (3) spring
Fundamental dynamic theorems and their application to the study of the motion of particles and rigid bodies, with particular emphasis on three-dimensional motion. Use of generalized coordinates; Lagrange’s equations and their applications. Prerequisites: Mech 102 or 103; Math 205. Johnson, Perreira. (ES 3), (ED 0)

Mech 305. Advanced Mechanics of Materials (3) fall
Strength, stiffness, and stability of mechanical components and structures. Fundamental principles of stress analysis: three-
dimensional stress and strain transformations, two-dimensional elasticity, contact stresses, stress concentrations, energy and variational methods. Stresses and deformations for rotating shafts, thermal stresses in thick-walled cylinders, curved beams, torsion of prismatic bars, and bending of plates. Projects relate analysis to engineering design. Prerequisites: Mech 12, Math 205. Nied. (ES 2.5), (ED 0.5)

Mech 307. Mechanics of Continua (3)
Fundamental principles of the mechanics of deformable bodies. Study of stress, velocity and acceleration fields. Compatibility equations, conservation laws. Applications to two-dimensional problems in finite elasticity, plasticity, and viscous flows. Prerequisites: Mech 305. Varley. (ES 3), (ED 0)

Mech 312. Finite Element Analysis (3) spring
Basic concepts of analyzing general media (solids, fluids, heat transfer, etc.) with complicated boundaries. Emphasis on mechanical elements and structures. Element stiffness matrices by minimum potential energy. Isoparametric elements. Commercial software packages (Abaqus, NISA) are used. In addition, students develop and use their own finite element codes. Applications to design. Prerequisites: Mech 12. Kahnins. (ES 1.5), (ED 1.5)

Mech 313. Fracture Mechanics (3) spring
Fracture mechanics as a foundation for design against or facilitation of fracture. Fracture behavior of solids; fracture criteria; stress analysis of cracks; subcritical crack growth, including chemical and thermal effects; fracture design and control, and life prediction methodologies. Prerequisites: Mech 12, Math 205, or approval of department. Nied, Wei. (ES 2), (ED 1)

Mech 326. Aerodynamics (3) spring
Application of fluid dynamics to flows past lifting surfaces. Normal force calculations in inviscid flows. Use of conformal mappings in two-dimensional airfoil theory. Kutta condition at a trailing edge; physical basis. Viscous boundary layers. Thin airfoil theory. Section design; pressure profiles and separation. Lifting line theory. Compressible subsonic flows; Prandtl-Glauert Rule. Airfoil performance at supersonic speeds. Prerequisites: ME 231 and Math 208. Blythe, Varley. (ES 2.5), (ED 0.5)

Mech 350. Special Topics (3)
A study of some field of engineering mechanics not covered elsewhere. Prerequisite: consent of the department chair.

Graduate Programs
The department offers programs of study leading to the degrees of master of science, master of engineering, and doctor of philosophy in mechanical engineering and computational and engineering mechanics.

Subject to approval, courses from other engineering curricula, such as materials science and engineering, and chemical, electrical, and industrial engineering, together with courses in mathematics and engineering mathematics, may be included in the degree program.

The intent of Computational and Engineering Mechanics is to promote and foster the continuing growth of a strong program in analytical, computational, and experimental mechanics, reinforced by expertise in the application of mathematics to the solution of problems in the engineering and physical sciences.

Master of Science in Mechanical Engineering
The M.S. degree program provides students with opportunities for more in-depth studies in mechanical engineering and mechanics and a broader background in related subject areas. In addition to a required two-course mathematics sequence (ME 442, ME 443), breadth is ensured through a series of required (three of four) core courses (ME 423, ME 430, Mech 408 and Mech 425). Depth is ensured through selected electives in the student's area of interest. A special program in Integrated Product Development (IPD) has different requirements, including ME 413, ME 442, and two new courses, ME 450A (Integrated Product Development) and ME 450B (Manufacturing).

A thesis option and a non-thesis option are offered. The thesis option is for students who wish to enhance their capabilities in mechanical engineering and mechanics and to gain research project experience in a team effort with a faculty member; it requires six credit hours of thesis in a specialized area. The non-thesis option is for students desiring to advance their expertise in mechanical engineering and mechanics through a concentrated course of study, and requires two three-credit-hour graduate courses in lieu of the thesis. A total of 30 approved credit hours is required. It is possible to complete the 30-credit degree in 11 months. A student whose background is different from that required in the undergraduate mechanical engineering curriculum or who has a particular deficiency may be required to present a larger number of credits than the minimum indicated for graduation.

A candidate for the M.S. in applied mechanics is expected to possess a thorough knowledge of undergraduate mathematics and mechanics. Math 205, 208 and 322, and Mech 302 and 305, or their equivalents, are considered prerequisites.

Master of Science in Computational and Engineering Mechanics
All students pursuing a master's degree in computational and engineering mechanics must take a minimum of 30 credit hours of graduate level work, with not less than 24 of these hours being at the 400 level. Their program must include the following three required courses:

Analytical Methods I & II Phys 428 & 429 or ME 442 & 443
Numerical Methods ME 413

In addition, they must take two of the four MEM core courses:

Heat and Mass Transfer ME 423
Advanced Fluid Mechanics ME 430
Introduction to Elasticity Mech 408
Analyst. Meth. in Dynamics & Vibs. Mech 425

The remaining 15 credits may be taken from any of the graduate courses in MEM and other approved electives.

Both thesis and non-thesis options will be available.

Doctor of Philosophy in Mechanical Engineering
A student who plans to work for the doctorate should submit a general plan to the department chair during the first year and arrange for the qualifying examination. Candidacy for the Ph.D. degree requires satisfactory completion of a qualifying examination, which emphasizes a broad grasp of fundamentals, and the formation of a special Ph.D. committee. In most cases, largely through the dissertation, the candidate emphasizes one or more specialized fields and engages in extensive research in collaboration with one or more faculty members. Research opportunities involve strong programs in both analysis and experimentation.

Doctor of Philosophy in Computational and Engineering Mechanics
Qualifying procedure
Students wishing to pursue a Ph.D. in computational and engineering mechanics must take the required core courses:

Analytical Methods I & II Phys 428 & 429 or ME 442 & 443
Numerical Methods ME 413
They must also take two core courses from the supplemental list given below:

- Asymptotic Methods Mech 419
- Integral Equations EMA 450
- Finite Element Methods Mech 418
- Non-deterministic Models in Engng. Mech 445
- Mechanical Reliability ME 446
- Heat and Mass Transfer ME 423*
- Advanced Fluid Mechanics ME 430*
- Introduction to Elasticity Mech 408*
- Analyt. Meth. in Dynamics & Vibs. Mech 425*

A student must attain a GPA of 3.35 for the five required courses taken. All students who satisfy the GPA requirement will be required to take a three-hour written examination in an area (special topic) of the student's choice. This topic is subject to approval by the computational and engineering mechanics graduate committee. For students who start in the program following their bachelor's degree, the written examination must be taken no later than the beginning of the fourth semester after entry. A student who fails the written examination will be allowed a single retake. The retake examination will be given at the end of the semester in which the examination was first attempted.

In addition, before completion of the degree, a student must have received graduate credit for at least two of the four MEM core courses which are designated by a * in the above list. If desired, these starred courses may be used as part of the Computational and engineering mechanics core, and hence count towards the core GPA requirement.

Research Facilities
The department has a wide range of computational, computer graphics and experimental systems. The department's CAD Lab has over 50 computers that include high-end engineering workstations. The university supports networks of hundreds of PCs as well as links to the Internet with thousands of on-line services.

Experimental facilities include 11 pulsed and continuous laser units for laser diagnostics in the areas of fluid and solid mechanics, four image processing systems and a number of unique facilities for observing and controlling flow past surfaces and through machines. There are well-equipped laboratories for multi-disciplinary studies of crack growth in deleterious environments and at elevated temperatures of up to 70°C, in conjunction with a number of surface analysis and electron microscopy facilities on campus. Extensively equipped, interdepartmental robotics, controls, and manufacturing laboratories are also available.

Other facilities include the latest mechanical, electrodynamic and servocontrolled hydraulic testing machines, photoelastic equipment, and Moiré strain measuring instruments.

Recent Research Activities
Continuum and solid mechanics. Formulation of field equations and constitutive equations in non-linear elasticity theories; mechanics of viscoelastic solids and fluids, plasticity theory; generalized continuum mechanics; thermomechanical and electromechanical interactions; analyses and modeling of manufacturing processes; free vibration and dynamic response of elastic shells, elastic-plastic deformation of shells upon cyclic thermal loading, and applications of shell analysis to nuclear power plant components; optical stress analysis; biomechanics of gait; wave propagation; finite amplitude wave propagation.

Fracture mechanics. Stress analysis of materials containing defects, including viscoelastic, non-homogeneous, and anisotropic materials; analytical and experimental studies and modeling of crack growth under static, periodic, and random loadings and environmental effects; optimizations of fracture control; crack propagation theories for nonlinear material; influence of cracks on the strength of structural members and of interfaces; hydraulic fracture; applications to reliability and durability of composites, structural and microelectronic components, and to processes for resource recovery.

Thermofluids. Structure of turbulent boundary layers, wakes and jets; vortex-solid boundary interactions; boundary layers in compressible flow, including hypersonic regimes; vortex breakdown in internal machinery and in flow past wings; drag reduction in turbulent flows; flow-induced noise and vibration; flutter of blades in axial-flow turbomachinery and of tails and fins on aircraft; unsteady aerodynamic flows past three-dimensional wings and bodies; flow structure and heat transfer at end-wall junctions in rotating machinery and on surfaces of aircraft; flows in micro-hydro-electromechanical systems; convective heat transfer in systems of electronic components; flows through complex components of power generation systems; transport of coal particles; flow and heat transfer in fluidized beds; cycle analysis applied to coal gasifiers; control optimization of heat pumps; laser-Doppler and particle velocimetry; liquid crystal sensors for heat transfer; Raman techniques applied to two-phase flow; laser diagnostics and image processing of complex flow and heat transfer systems.

Theoretical fluid mechanics. Vortex boundary layer interaction, modeling of turbulent boundary layers; geophysical flows such as frontal systems and mountain flows; statistical mechanics of plasmas, liquids and shock waves; finite amplitude waves in stratified gases and liquids; shock wave propagation; non-Newtonian flows in flexible tubes with application to hemorheology; magneto-fluid mechanics; wing theory; thermally driven flows.

Design. Geometric modeling; tolerance analysis and synthesis; assembly modeling; geometric dimensioning and tolerancing; 3-D digitizing; data and information structures; design for manufacturing; design methodology, tools and practices; expert systems in design; industry projects with Integrated Product Development (IPD) focus.

Manufacturing. Free-form surface machining; coordinate measuring machine applications to geometric dimensions and tolerances; Taguchi’s method; injection molding; sheet metal fabrication; FEA/FEM applications to plastic deformation of metals; rapid prototyping; intelligent manufacturing; incorporating process modeling, sensor subsystems for in situ product quality monitoring, and knowledge-based control for real-time process adaptation; blow molding; composites processing; thermoforming; resin transfer molding; spin coating; electronic packaging.

Systems Dynamics and Controls. Modeling and advanced simulation of dynamic systems including vehicles, chemical processes, aerelastic structures, and heat-pump systems; methods of experimental identification and analysis of distributed-parameter systems including microelectromechanical components, space deployment platforms; energy methods and bond graphs in modeling; stochastic optimal control techniques applied to stable platform for overlaid vehicles; conceptualization and hardware development of innovative components and systems for fluid power control; application of robotics to manufacturing; computer-controlled theater lighting design.

Stochastic processes. Modeling of random behavior in mechanical systems; static and time-dependent stochastic fracture mechanics, with particular applications to assessments of reliability and service life prediction.

Graduate Courses in Mechanical Engineering
Except for core courses, graduate courses are generally offered every third semester. Several courses are offered each year as ME 450 Special Topics. For details, contact the graduate office of the department.

ME 411. Boundary-Layer Theory (3)
The course is intended as a first graduate course in viscous flow. An introduction to boundary-layer theory, thermodynamics and heat transfer at the undergraduate level are assumed to have been completed. Topics include the fundamental equation of continuum fluid mechanics, the concept of asymptotic methods and low and high Reynolds number flows, laminar boundary layers, generalized similarity methods, two- and three-dimensional flows, steady and unsteady flows and an introduction to hydrodynamic stability. The material is covered in the context of providing a logical basis as an introduction to a further course in turbulent flows. Walker, Liakopoulos

ME 413. Numerical Methods in Mechanical Engineering (3)

ME 415. Flow-Induced Vibrations (3)

ME 420. Advanced Thermodynamics (3)

ME 421. Topics in Thermodynamics (3)
Emphasis on theoretical and experimental treatment of combustion processes including dissociation, flame temperature calculation, diffusion flames, stability and propagation; related problems in compressible flow involving one-dimensional, oblique shock waves and detonation waves. Methods of measurement and instrumentation. Staff

ME 423. Heat and Mass Transfer (3)
This course is a first graduate course in the basic concepts of heat and mass transfer, providing a broad coverage of key areas in diffusion, conduction, convection, heat and mass transfer, and radiation. Topics covered include: the conservation equations, steady and transient diffusion and conduction, periodic diffusion, melting and solidification problems, numerical methods, turbulent convection, transpiration and film cooling, free convection, heat transfer with phase change, heat exchanges, radiation, mixed mode heat and mass transfer. Walker, Neti, Oztekin

ME 424. Turbulent Flow (3)
Stability of laminar flow; transition to turbulence. Navier-Stokes equations with turbulence. Bounded turbulent shear flows; free shear flows; statistical description of turbulence. Prerequisite: ME 331. Rockwell

ME 426. Radiative and Conductive Heat Transfer (3)
Principles of radiative transfer; thermal-radiative properties of diffuse and specular surfaces; radiative exchange between bodies; radiative transport through absorbing, emitting and scattering media. Advanced topics in steady-state and transient conduction; analytical and numerical solutions; problems of combined conductive and radiative heat transfer. Prerequisite: ME 321 or ChE 421. Varley

ME 427. (ChE 427) Multiphase Flow and Heat Transfer (3)
Heat transfer and fluid dynamics of multiphase systems. Subcooled, nucleate, and film boiling; bubble nucleation; dynamics of bubble growth and collapse; vapor-liquid cocurrent flow regimes; two-phase pressure drop and momentum exchange, low instabilities; convective-flow boiling; simultaneous heat and mass transfer. Prerequisite: ME 321 or ChE 421. Chen

ME 428. Boundary Layers and Convective Heat Transfer (3)
Navier-Stokes and energy equations, laminar boundary layer theory, analysis of friction drag, transfer and separation. Transition from laminar to turbulent flow. Turbulent boundary layer theory. Prandtl mixing length, turbulent friction drag, and heat transfer. Integral methods. Flow in ducts, wakes and jets. Natural convection heat transfer. Prerequisite: ME 331 or ME 321. Levy, Liakopoulos

ME 430. Advanced Fluid Mechanics (3)
This course is a first graduate course in incompressible fluid mechanics, providing a broad coverage of key areas of viscous and inviscid fluid mechanics. Topics covered include: Flow kinematics, differential equations of motion, viscous and inviscid solutions, vorticity dynamics and circulation, vorticity equation, vortex theorems, potential flow behavior, irrotational and rotational flows, simple boundary layer flows and solutions, and real fluid flows and consequences. Smith, Rockwell

ME 431. Advanced Gas Dynamics (3)

ME 433. (ChE 433, ECE 433) State Space Control (3)
State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin’s Maximum Principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal open loop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: ME 343 or ECE 212 or ChE 386 or consent of instructor. Johnson, Georgakis

ME 434. (ChE 434, ECE 434) Multivariable Process Control (3)
A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feed forward control, internal model control
and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor. Georgakis

ME 436. (ChE 436, ECE 436) Systems Identification (3)
The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasilinearization and invariant-embedding techniques for nonlinear system parameter identification included. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor. Johnson

ME 437. (ChE 437, ECE 437) Stochastic Control (3)
Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gaussian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor. Staff

ME 439. Fluid Mechanics of Turbo-machinery (3)

ME 442. Analytical Methods in Engineering I (3) fall
Analytical methods of solution for discrete and continuous engineering systems. Theoretical, numerical and approximate methods of solution applied to equilibrium, characteristic value and propagation types of engineering problems. Staff

ME 443. Analytical Methods in Engineering II (3) spring
Continuation of ME 442.

ME 444. Experimental Stress Analysis in Design (3)
Fundamental concepts of strain measurements and application of strain gages and strain gage circuits. Two- and three-dimensional photoelasticity, stress separation techniques, birefringent coatings, moiré methods, caustics. Use of image analysis in data acquisition and interpretation. Selected laboratory experiments. Voloshin

ME 446. Mechanical Reliability (3)
Design of mechanical engineering systems to reliability specifications. Probabilistic failure models for mechanical components. Methods for the analysis and improvement of system reliability. Effect of component tolerance and parameter variation on system failure. Reliability testing. Prerequisite: Math 231 or Math 309. Harlow

ME 450. Special Topics (3)
An intensive study of some field of mechanical engineering not covered in more general courses.

ME 451. Seminar (1-3)
Critical discussion of recent advances in mechanical engineering.

ME 458. Modeling of Dynamic Systems (3)
Modeling of complex linear and nonlinear energetic dynamic engineering systems. Emphasis on subdivision into multiport elements and representation by the bondgraph language using direct, energetic, and experimental methods. Field lumping. Analytical and graphical reductions. Simulation and other numerical methods. Examples including mechanisms, electromechanical transducers, electric and fluid circuits, and thermal systems. Brown, Johnson

ME 460. Engineering Project (1-6)
Project work on some aspect of mechanical engineering in an area of student and faculty interest. Selection and direction of the project could involve interaction with local communities or industries. Prerequisite: consent of the department chair.

ME 464. Computer-Aided Geometric Modeling (3)
Representation schemes for geometric modeling, computational geometry for curve and surface design, finite-element meshing and NC tool path generation, interfacing different CAD/CAM databases, interactive computer graphics programming. Prerequisite: ME 348 or consent of instructor. Ozsoy

ME 466. Fundamentals of Acoustics (3)

ME 490. Thesis

ME 499. Dissertation

Graduate Courses in Engineering Mechanics

Except for core courses, graduate courses are generally offered every third semester.

Mech 402. Advanced Analytical Mechanics (3)
Fundamental dynamical theorems and their applications to advanced problems; generalized coordinate; Lagrange's equations; fixed and moving constraints; nonholonomic systems; Hamilton's principle; Hamilton's canonical equations; contact transformations; Hamilton-Jacobi partial differential equation. Prerequisite: Mech 302 or consent of the department chair. Johnson

Mech 405. Response of Systems to Random Loads (3)
Stochastic processes; correlation functions and power spectra; response of mechanical systems to one-dimensional and multidimensional random load fields; probability of the random vibrations of mechanical systems; applications to failure prediction. Prerequisite: consent of the department chair. Harlow

Mech 406. Advanced Dynamics and Vibrations (3)
Kinematical and mathematical preliminaries, basic notions of variational calculus; Hamilton's principle. Lagrange equations, discrete systems; dynamics of continuous systems. Sturm-Liouville theory, eigenvalue problems; transient and frequency response. There will be frequent examples of the application of these techniques to the analysis of shafts, beams, membranes, and plates. Prerequisites: ME 242 and Mech 302. Erdogan, Johnson

Mech 407. Wave Propagation in Solids (3)
Wave propagation in deformable elastic solids; problems in halfspace and layered media; application of integral transformations. Erdogan, Delph, Varley

Mech 408. Introduction to Elasticity (3) fall
This course is a first graduate course in solid mechanics. It addresses: kinematics and statics of deformable elastic solids; compatibility, equilibrium and constitutive equations; problems in plane elasticity and torsion; energy principles, approximate methods and applications. Staff

Mech 409. Theory of Elasticity I (3)
Kinematics of deformation, analysis of stress, stress-strain relations, strain energy function. Reciprocal theorem. Methods for two-dimensional boundary value problems applied to anti-
Mech 410. Theory of Elasticity II (3)
Advanced topics in the theory of elasticity. The subject matter may vary from year to year and may include, theory of potential functions, linear thermoelasticity, dynamics of deformable media, integral transforms and complex-variable methods in classical elasticity. Problems of boundary layer type in elasticity; current developments on the micro-structure theory of elasticity. Prerequisites: Mech 409, Math 208, or consent of the department chair. Erdogan

Mech 411. (Phys 471) Continuum Mechanics (3)
An introduction to the continuum theories of the mechanics of solids and fluids. This includes a discussion of the mechanical and thermodynamical bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of the theories to specific problems are given. Staff

Mech 412. Theory of Plasticity (3)

Mech 413. Fracture Mechanics (3)
Elementary and advanced fracture mechanics concepts; analytical modeling; fracture toughness concept; fracture toughness testing; calculation of stress intensity factors; elastic-plastic analysis; prediction of crack trajectory; fatigue crack growth and environmental effects; computational methods in fracture mechanics; nonlinear fracture mechanics; fracture of composite structures; application of fracture mechanics to design. Prerequisites: Math 205, Mech 305 or equivalent course in advanced mechanics of materials. Erdogan, Hartranft

Mech 414. Viscoelasticity and Creep (3)
Mechanical models for linear viscoelastic materials, representations by differential operators and hereditary integrals, creep and relaxation functions, correspondence principle, quasi-static analysis, wave propagation, nonlinear material behavior, uniaxial creep laws, multiaxial generalizations, creep damage and failure. Prerequisite: Mech 408. Delph

Mech 415. (CE 468) Stability of Elastic Structures (3)
Basic concepts of instability of a structure; bifurcation, energy increment, snap-through, dynamic instability. Analytical and numerical methods of finding buckling loads of columns. Postbuckling deformations of cantilever columns. Dynamic buckling with nonconservative forces. Effects of initial imperfections. Inelastic buckling. Instability problems of thin plates and shells. Prerequisite: Math 205. Kalnins

Mech 416. (CE 464) Analysis of Plates and Shells (3)
Bending of rectangular and circular plates, plates under lateral loads, plates with thermal and inelastic strains, effect of initial stresses, large deflections. Geometry and governing equations of a shell, shells of revolution, membrane states, edge solutions, solution by numerical integration, applications to pressure vessels. Prerequisites: Math 205; Mech 305 or equivalent course in advanced mechanics of materials. Kalnins

Mech 417. Mixed Boundary Value Problems in Mechanics (3)

Mech 418. Finite Element Methods (3)
Finite element approximations to the solution of differential equations of engineering interest. Linear and nonlinear examples from heat transfer, solid mechanics, and fluid mechanics are used to illustrate applications of the method. The course emphasizes the development of computer programs to carry out the required calculations. Prerequisite: knowledge of a high-level programming language. Delph

Mech 419. (ChE 419) Asymptotic Methods in the Engineering Sciences (3)

Mech 422. Fluid Mechanics (3)
Similarity and dimensional analysis. Exact solution for viscous incompressible flow. Singular perturbation theory, with application to flows at low and high Reynolds number. Hydrodynamic stability. Depending on interest, additional topics from Magnetohydrodynamics, kinetic theory, wing theory, turbulence, water waves, flows in flexible tubes. Prerequisite: ME 430. Staff

Mech 424. Unsteady Fluid Flows (3)
Gas dynamics, finite amplitude disturbances in perfect and real gases; channel flows; three-dimensional acoustics; theories of the sonic boom. Motions in fluids with a free surface; basic hydrodynamics, small amplitude waves on deep water; ship waves; dispersive waves; shallow water gravity waves and atmospheric waves. Hemodynamics; pulsatile blood flow at high and low Reynolds number. Models of the interaction of flow with artery walls. Varley

Mech 425. Analytical Methods in Dynamics and Vibrations (3)
This course is a first graduate course in dynamics and vibrations. It treats three-dimensional rigid body motion by vector methods and multidegree of freedom systems by variational principles. Discrete modal analysis and continuous modal analysis of one-dimensional systems plus finite-element formulation of numerical problems constitutes one-third of the course. There is a brief treatment of advanced impact. Use of symbolic computer codes is encouraged. Johnson

Mech 437. (Mat 437) Dislocations and Strengths in Crystals (3)
Theory and application of dislocations. Geometrical interpretation; elastic properties; force on a dislocation; dislocation interactions and reactions; multiplication. Dislocations in crystal structures. Selected topics in strengthening plastic flow, creep, fatigue and fracture are discussed. Prerequisites: Math 205 or 231, or Mat 320; Mat 317, or consent of the department chair. Smith

Mech 445. Non-deterministic Models in Engineering (3)
Application of probability and stochastic processes to engineering problems for a variety of applications. Modeling and analysis of common non-deterministic processes. Topics are selected from the following: linear and nonlinear models for random systems; random functions; simulation; random loads and vibrations; Kalman filtering, identification, estimation, and
prediction; stochastic fracture and fatigue; probabilistic design of engineering systems; and spatial point processes. Prerequisites: advanced calculus and some exposure to probability and statistics. Harlow

Mech 450. Special Problems (3)
An intensive study of some field of applied mechanics not covered in more general courses.

Mech 454. Mechanics and Design of Composites (3)
Mechanics of anisotropic materials. Manufacturing and measurements of mechanical properties. Stress analysis for design of composite structures. Hygrothermal effects and residual stresses. Laminate design, micromechanics of lamina. Bolted and bonded joints. Impact and damage in composites. Lectures and laboratory. Prerequisite: Mech 305 or equivalent course in advanced mechanics of materials. Voloshin

Mech 490. Thesis

Mech 499. Dissertation

Graduate Courses in Engineering Mathematics
Students in the applied mathematics program also have access to the graduate courses listed under mechanical engineering, engineering mechanics, and mathematics, as well as other engineering departments.

EMA 425. Variational Methods in Science and Engineering (3)
Variational problems with one independent variable; Euler-Lagrange equations; methods of solution; space and time dependent fields; null Lagrangians and inhomogeneous Dirichlet data; problems with constraints; symmetries and conservation laws; variational approximation methods, Rayleigh-Ritz, Galerkin, finite element, and collocation. Problems and examples will be drawn from the mechanics of solids, fluids, and related fields. Prerequisite: consent of chair. Staff

EMA 450. Special Topics (3)
An intensive study of some field of engineering mathematics not covered in other courses.

EMA 490. Thesis

EMA 499. Dissertation

Military Science

Professor. MAJ. Margie E. Griffith, M.S. (Indiana University), chair.
Assistant professors. MAJ Thomas E. Detrick, M.S. (Florida Institute of Technology); CPT James R. Hanson IV, B.S. (University of Central Florida); CPT Robert J. Kelly, B.S. (University of Scranton).
Instructors. MSG James R. Landers; SFC Thomas Gleason; SSG Lavant Livers.

The Department of Military Science, established in 1919, conducts the Army Reserve Officers Training Corps (ROTC) program at Lehigh University. This is one of the oldest ROTC programs in the nation. The Army ROTC program provides a means for students to qualify for a commission as an officer in the Active Army, Army Reserve, or Army National Guard.

The objectives of the military science program are to develop leadership and management ability in each student; to provide a basic understanding of the Army's history, philosophy, organization, responsibilities, and role in American society; and to develop fundamental professional knowledge and skills associated with officership. These objectives are achieved through classroom instruction, leadership laboratories, field trips, role playing, leadership simulations, and individual assessment and counseling. Army ROTC offers a four-year program and a two-year program. The four-year program consists of a two-year basic course and a two-year advanced course. The two-year program consists of the two-year advanced course offered to students with previous military experience, and those who have successfully completed a six-week ROTC basic summer camp. Basic course students incur no obligation for service in the Army as a result of taking these courses.

Basic Course. The basic course, normally taken in the freshman and sophomore years, provides training and instruction in leadership, public speaking, and basic military subjects, such as the Army's role and organizational structure, history and philosophy of the Army, basic tactics, land navigation, first aid, group dynamics, and leadership traits and characteristics. Basic course students incur no military obligation.

Advanced Course. The advanced course is normally taken in the junior and senior years. The instruction includes management, military skills, advanced leadership and tactics, logistics, administration, military law, ethics, and professionalism, and includes attendance at ROTC Advanced Camp. Students receive $150 per month subsistence pay during the junior and senior years.

To enroll in the advanced course, an applicant, completes either the basic course or the six-week basic summer camp; or has received basic course credit for previous military experience; or is a nursing student and is accepted for enrollment by the university and the Department of Military Science.

Uniforms and Equipment. All uniforms and equipment needed by the student for military science courses are supplied by the department. Students are charged only for those items not returned when they leave the program.

Transfers. Qualified students transferring from another institution may enter the ROTC program at the appropriate level and year, provided they have received the necessary credits, the recommendation of their former professor of military science (if applicable), and the approval of the university.

Obligation after graduation. Upon graduation, a student will receive a commission as a Second Lieutenant in either the Active Army or the Reserve Forces. If offered active duty, scholarship students serve four years while non-scholarship students serve three. If offered reserve duty, students normally serve six to eight years in a Reserve or National Guard unit.

Graduate studies. ROTC graduates may request to delay their active service to pursue a full-time course of instruction leading to an advanced degree. Delay does not lengthen the active service obligation unless the degree is obtained at government expense. The three major areas of concentration are medical school, law school, and all other categories.

Course credit. Students in the College of Arts and Sciences and the College of Business and Economics may substitute military science advanced credits for six hours of electives. In the College of Engineering and Applied Science, six credits of advanced ROTC work are permissible within the normal program of each student, irrespective of curriculum. For curricula that include more than six hours of personal electives in the junior and senior years, inclusion of the more than six hours of ROTC credit with normal programs can be effected only with the approval of academic advisors. All military science credits, including those in the basic course, apply toward the student's overall cumulative grade point average.

Career Opportunities
Individuals are commissioned as officers in the United States Army after completion of the ROTC program and the advanced camp and completion of their bachelor's degree requirements. They then qualify in branches (specialties) such as the Corps of Engineers, Infantry, Armor, Aviation, Field Artillery, Air Defense Artillery, Signal Corps, Military Intelligence, Chemical Corps, Ordnance Corps, Finance, Transportation, Military Police,
Adjutant General, Quartermaster, Medical Service Corps, or Nursing. Officers work as leaders/managers, specialists, or combinations of the two depending on the assignment.

Programs and Opportunities

ROTC Scholarship Program. This program is designed to offer financial assistance to outstanding young men and women entering the ROTC program who are interested in an Army career. Scholarships provide up to $20,000 annual tuition, a textbook and supplies allowance, and laboratory fees, in addition to pay of $150 per month for the period the scholarship is in effect. Three-year and two-year scholarships are available to outstanding cadets who are currently enrolled in the four-year ROTC program and are completing their freshman or sophomore year of college. This program is also open to all qualified students who are not currently enrolled in Army ROTC.

Four-year scholarships are open to all students entering ROTC as freshmen. Applications for scholarship must be made to Headquarters, U.S. Army Cadet Command, Fort Monroe, VA by July 15th prior to the senior year for early selection, but no later than November 15th for normal application. Applications may be obtained by calling 1-800-USA-ROTC. Application booklets are also available from most high school guidance offices, or may be obtained from the military science department.

Two-Year Program. Students who want to enroll in ROTC after their sophomore year may apply. Applicants must successfully complete a five-week basic ROTC summer camp and have two years of undergraduate or graduate studies remaining. The student is paid for the five-week encampment and receives transportation costs to and from the camp.

Additional scholarships are available at this camp.

Physical facilities. Army ROTC uses areas on and adjacent to the university campus to conduct field training. These locations are excellent for outdoor activities such as orienteering, patrolling, and survival training. Fort Indiantown Gap Military Reservation, located east of Harrisburg, PA, and Fort Dix, NJ, located east of Philadelphia, PA, are used for field training exercises and weapons familiarization during the two annual weekend field exercises. Gettysburg National Park and the Pentagon are also visited each year.

Off-campus U.S. Army Training Schools. Cadets may be selected to attend the following U.S. Army Schools: Airborne School (Fort Benning, Georgia), Air Assault School (Fort Campbell, Kentucky), Mountain Warfare School (Ethan Allen Training Center, Vermont), and Northern Warfare School (Fort Greely, Alaska). This off-campus program is fully funded by the U.S. Army. Many other installations throughout the world may be visited through the Cadet Troop Leader Training program.

Nursing students may attend the Nurse Summer Training Program at Army hospitals located throughout the United States.

Minor in Military Science. A minor in military science is available in the College of Arts and Sciences. A minor in military science consists of 37 credit hours beyond the basic Military Science course and is designed to provide the student with an academic foundation necessary to support continued intellectual growth and stimulate future inquiry in the realm of civil military affairs and military science. Credit hours required are distributed as follows:

- Military Science (12)
- MS 101 Advanced Military Skills (3)
- MS 102 Advanced Leadership (3)
- MS 113 Military Command and Staff (3)
- MS 114 Officer Responsibilities, Ethics and Military Professionalism (3)
- MS 118 Special Military Topics (1)

History (3)
Hist 110 American Military History (3)

International Relations (3)
(Select one course from one of the following categories)
International Relations
Political Science

Written Communications (3)
(Select one course from one of the following categories)
Creative Writing
Scientific Writing
Writing for Mass Communications

Human Behavior (3)
(Select one course from one of the following categories)
General Psychology
Sociology
Anthropology
Ethics

Foreign Language (6)
Math (3)

Computer Literacy (3)

Commissioning Requirements
Individuals must complete either the two- or four-year programs, attend the advanced camp, receive a college degree, have a cumulative GPA of 2.0, and complete all professional military education requirements to become commissioned officers in the United States Army.

Course Descriptions

Leadership Laboratory is conducted for all students on three Sundays per semester. The Leadership Laboratory provides students the opportunity to demonstrate an understanding of the leadership process and develop fundamental military skills.

Instruction at several levels on a variety of subjects with military application provides the context within which students are furnished opportunities to both teach and lead in a group setting. Responsibility is expanded as the student progresses through the program. In the senior year, the students assume the responsibility for the planning, preparation and conduct of the laboratory. Leadership Laboratory is mandatory for all students enrolled in military science courses.

MS 15. Introduction to Military Science (1) fall
The American Army as an institution, its roots, history, customs and traditions and philosophy of leadership. Emphasis on development and role of a professional officer corps. Includes leadership laboratory.

MS 16. Leadership Assessment and Group Dynamics (1) spring
Role of individual and leader within the group, leadership skills and characteristics. Emphasis on problem solving and application. Includes laboratory and FTX.

MS 23. Topographic Analysis and Land Navigation (2) fall
Maps as tools in basic terrain analysis and as navigational aids and introduction to small unit tactics. Emphasis on application and field exercises at individual and small group levels. Includes laboratory and FTX.

MS 24. Leadership Theory and Management (2) spring
Contemporary theories, traits and principles and small unit tactics development. Leadership philosophies, communications, leader-follower relationships, and leadership problem-solving. Leadership simulations. Includes laboratory and FTX. Note: Credit for this course will count as GPA but not credit toward a degree.
MS 101. Advanced Military Skills (3) fall
Essential junior officer skills: advanced land navigation, principles of war, small unit tactical planning, tactics and techniques of the soldier, team leading techniques, oral communications and trainer skills. Emphasizes application and field experience. Includes laboratory and FTX. Prerequisite: permission of department chair.

MS 102. Advanced Leadership (3) spring
Critical examination of leadership qualities, traits and principles with emphasis on military environment. Self, peer, and instructor leadership evaluation. Advanced military skills reinforced. Includes laboratory, FTX and a five-day leadership exercise. Prerequisite: permission of department chair.

MS 113. Military Command and Staff (3) fall
Role, authority and responsibility of military commanders and staff in personnel, logistics and training management. Staff procedures, problem solving, training methods and oral and written communications skills used in military organizations. Includes leadership laboratory and FTX. Prerequisite: permission of department chair.

MS 114. Officer Responsibilities, Ethics and Military Professionalism (3) spring
Development of the Profession of Arms, its fundamental values and institutions. Ethical responsibilities of military professionals in contemporary American society. Just war theory, international law of war, and American military law. Also covered are current topics to assist cadets in making the transition to the officer corps and service on active duty or in the reserve forces. Includes leadership laboratory and FTX. Prerequisite: permission of department chair.

MS 118. Special Topics for the Army Officer (1) fall, spring
Seminar covering special problems and issues dealing with responsibilities of the commissioned officer as leader, manager, and mentor, not covered in other courses. Prerequisite: permission of department chair.

Advanced ROTC Summer Camp
This is a five-week training program normally conducted at Fort Lewis, WA. Prerequisites are completion of the basic military science courses or their equivalent and MS 101 and 102. The summer camp experience, in coordination with respective employment requirements of the engineering courses, CE 100, IE 100, and Mat 100.

Modern Languages and Literature

Professors. David W. Pankenier, Ph.D. (Stanford), Chinese; Lenora D. Wolfgang, Ph.D. (Pennsylvania), French.
Associate professors. Marie-Sophie Armstrong, Ph.D. (Oregon), French; Marie-Hélène Chabut, Ph.D. (U.C., San Diego), French; Constance Cook, Ph.D. (Berkeley), Chinese; Linda S. Lefkowitz, Ph.D. (Princeton), Spanish; Mary Nicholas, Ph.D. (Pennsylvania), Chair, Russian; Antonio Prieto, Ph.D. (Princeton), Spanish; Vera S. Stegmann, Ph.D. (Indiana), German; D. Alexander Waldenrath, Ph.D. (Berkeley), German.

Knowledge of other languages opens the door to other cultures, traditions, and perspectives on the world, and promotes deeper insight into one's own language and culture. Proficiency in foreign languages is indispensable in a broad range of professions such as journalism, government, international affairs, law, the armed forces, and business. A bachelor of arts degree with a major in languages provides excellent preparation for professional careers in law, business, and the media. Foreign language study is required for graduate study in many disciplines, as well as for research in science and technology. International experience is personally enriching and enhances career prospects.

Languages offered
Lehigh offers Mandarin Chinese, French, German, Hebrew, Japanese, Russian, and Spanish.

Courses include writing and speaking, reading and listening, literature, civilization, and professional areas such as business and health careers. A number of cultural courses are given in English, but most offerings stress classroom use of the language. Facilities include an International Multimedia Resource Center (IMRC). Within the IMRC in Maginnes Hall are a state-of-the-art multimedia computer lab (Maginnes 470) dedicated primarily to foreign language multimedia and World Wide Web applications and the World View Room (Maginnes 490) in which is shown a regular daily schedule of foreign language news and feature programming received via international satellite TV networks.

Language requirements
The honors major in international relations requires foreign language study. The college scholar program in the College of Arts and Sciences; the major in Russian and Soviet studies, the major in Asian studies, the minors in Latin American studies, Russian area studies, Asian studies, and in military science require language study. Students taking the B.A. in international relations or in foreign careers are expected to study a language. Students choosing a foreign language at an elementary level towards their general studies requirement in the college of engineering must take a minimum of one year (two courses). Some doctoral programs also require foreign language competence, usually assessed by the Department of Modern Languages and Literature.

Advising. Because of the sequential nature of language study and the variety of specializations available, the department pays special attention to student advising. Students whose experience, skills, and placement scores (Advanced Placement or College Board Achievement Test) do not give them a clear indication of their level of placement should consult with their instructor or the department chair. Faculty members responsible for more advanced advising are currently as follows: Chinese minor and Asian studies major and minor, Pankenier; French major, Chabut; French minor, Armstrong; German major and minor, Stegmann; Russian minor and area studies, Nicholas; Spanish major, Prieto, Spanish minor, Lefkowitz.

Major programs. The department offers major programs in Asian studies, French, German, Russian studies, and Spanish. The candidate for the major is expected to demonstrate adequate written and oral command of the language, as well as knowledge of its literature and culture. A period of study abroad is strongly recommended.

Double majors and arts-engineering majors including a language component are well-received by employers. Studies in the two areas are carefully coordinated by major advisers.

Requirements for the major. A minimum of 32 credit hours is required beyond Intermediate II, chosen from Groups A and B below:
Group A: one to four required courses (variable, depending on language major).
Group B: four to seven electives chosen from 100-300 level courses with emphasis on 300-level courses.

For specific course requirements, see each language major adviser.

Language students may count one MLL course taught in English toward the major in French, German, and Spanish.
Requirements for the departmental honors major. Same as for the major plus eight additional hours of advanced courses at the 300 level, dissertation or comprehensive examination (written or oral), and a 3.20 average in the major.

Minor programs. The department offers minor programs in Asian studies, Chinese, French, German, Latin American studies, Russian, Russian studies, and Spanish and coordinates these studies with a student's major requirements in any college.

Requirements for the minor. 16 credit hours are required above Intermediate II: one or two courses at the 200 level, one or two courses at the 300 level. A minimum of 16 credit hours for Chinese and Russian.

Related programs. These are available in Asian studies, foreign careers, Jewish studies, Latin American studies, and Russian and Soviet studies. Recommended related courses. Students are urged to take elective courses on related subjects, either within or outside the department, as approved by their adviser.

Preliminary courses. These may be replaced by other courses when a student qualifies for advanced standing.

Language of instruction. All courses are taught in the target language except MLL courses listed under "Foreign Culture and Literature Taught in English." Students thereby become accustomed to considering the language as an active means of communication and not solely as an object of study.

Courses in English. The department offers elective courses in English on literary, cultural, and social subjects listed under "Foreign Culture and Literature Taught in English." These courses may, in most cases, be taken to fulfill preliminary distribution requirements. One of these courses may be included in the major.

Study Abroad and Foreign Study Awards. The department encourages students of foreign languages to spend a summer, a semester, or a full year on an approved program of study abroad. Exchange agreements with partner institutions are continually being developed. The department offers a limited number of travel scholarships for foreign study to qualified students. Applications should be submitted by November 1 for the spring semester and by April 1 for summer or fall. For credit, transfer students must consult in advance with their major adviser, foreign language adviser, or other appropriate departments, the Office of International Education, and, when appropriate, the Office of Financial Aid.

Lehigh offers summer programs through the Lehigh Valley Association of Independent Colleges (LVAI). Programs are offered in Poitiers (France), Bonn (Germany), and Seville (Spain) for six credits each. A faculty member acting as program director accompanies the students. Courses are taught at intermediate and advanced levels by qualified instructors from host institutions. Summer programs sponsored by the Lehigh-LVAI Center for Jewish Studies include Hebrew in Israel.

Credits and grades are fully transferable under normal LVAI cross-registration procedures. Interested students should consult with the Department of Modern Languages and Literature, Maginnis Hall.

These courses are offered by Lehigh or under the cooperation agreement with the Lehigh Valley Association of Independent Colleges. Summer or semester study abroad at approved programs may be incorporated into foreign language majors and minors with the permission of the appropriate advisor to a maximum of 16 credits toward the major and eight credits toward the minor.

Chin, Jpns, Russ 91. Language and Culture Abroad I (1-8) Intensive study of conversation in the language of the country; reading, development of writing skills and selected aspects of the culture. (HU)

Chin, Fren, Germ, Jpns, Russ, Span 191. Language and Culture Abroad II (1-8) Intensive study of conversation in the language of the country; rapid review of basic grammar, the reading and analysis of moderately difficult texts, development of rudimentary writing skills, supplemented study of selected aspects of contemporary civilization. Prerequisites: consent of chair and proficiency examination in the target country.

Chin, Fren, Germ, Jpns, Russ, Span 291. Language and Culture Abroad III (1-8) Intensive practice of speaking and writing in the language of the country aimed at providing the student with extensive proficiency of expression and the ability to discriminate linguistic usage. Idiomatic expressions and an introduction to stylistics. Reading and analysis of more difficult texts, supplemented by in-depth study of selected aspects of contemporary civilization. Prerequisites: consent of chair and proficiency examination in the target country.

Foreign Culture and Literature Taught in English These courses on foreign cultures and comparative topics carry no prerequisites; knowledge of the foreign language is not required.

Language majors may count one MLL course taught in English for credit toward a major requirement. Interested students should consult their language major advisers. For course descriptions, see under each language area below.

MLL 23. Lehigh in Russia (1-8)

MLL 27. Russian Classics (4)

MLL 43. German Literature in Translation (4)

MLL 51. Contemporary Hispanic-American Literature (4)

MLL 53. This Hispanic World and its Culture (4)

MLL 68. (Asia 68) Japanese Language: Past and Present (4)

MLL 73. (Asia 73) Fiction into Film: Modern Chinese Literature in Translation (4)

MLL 74. (Asia 74) Chinese Cultural Program (1-8)

MLL 75. (Asia 75, Hist 75) Chinese Civilization (4)

MLL 78. (Asia 78) Asian American Studies (4)

MLL 125. (Asia 125) Immortal Images: Traditional Chinese Literature in Translation (4)

MLL 140. (CogS 140, Anth 140, PsyC 140) Introduction to Linguistics (4)

Relationship between language and mind; formal properties of language; language and society; how languages change over time. (SS)

MLL 173. The Literature of the Americas (4)

MLL 177. (Asia 177, Hist 177) China Enters the Modern Age (4)

MLL 349. (Hist 349) Cultural History of Medieval Russia (4)
Courses Taught in Chinese

Chin 1. Elementary Chinese I (4) fall
Spoken and written Mandarin Chinese; the Pinyin transcription system used in the People's Republic of China; introduction to Chinese calligraphy, pronunciation, basic speech patterns and vocabulary. Weekly laboratory and conversation practice. (HU)

Chin 2. Elementary Chinese II (4) spring
Continuation of Chin I; more vocabulary and sentence patterns, reading and writing Chinese characters. Weekly video laboratory and conversation practice. Prerequisite: Chin 2 or equivalent. (HU)

Chin 11. Intermediate Chinese I (4) fall
Advanced character texts and vocabulary; folktales, brief readings in Chinese. Weekly laboratory and conversation practice. Prerequisite: Chin 11 or equivalent. (HU)

Chin 12. Intermediate Chinese II (4) spring
Continuation of Chin 11; oral and written exercises. Weekly laboratory and conversation practice. Prerequisite: Chin 12 or equivalent. (HU)

Chin 41. Modern Written Chinese I (1-4) fall
Reading and writing modern colloquial Chinese: emphasis on character acquisition and written expression. Suitable especially for students who need additional work with Chinese characters to supplement existing oral skills. Prerequisite: Chin 2 or equivalent and consent of the instructor. (HU)

Chin 42. Modern Written Chinese II (1-4) spring
Continuation of Chin 41. Prerequisite: Chin 41, or equivalent and consent of the instructor. (HU)

Chin 141. Advanced Chinese I (4) fall
Advanced reading and oral comprehension; film, prose, poetry, journalistic Chinese. Conversation and writing practice. Prerequisite: Chin 12 or equivalent. (HU)

Chin 142. Advanced Chinese II (4) spring
Continuation of Chin 141; more advanced readings, conversation, and composition. Prerequisite: Chin 141 or equivalent. (HU)

Chin 251. Special Topics (1-4)
Literary and linguistic topics not covered in regular courses. May be repeated for credit. Prerequisite: consent of the instructor. (HU)

Chin 371. Special Topics (1-4)
Directed study of an author, genre, or period not covered in regular courses. May be repeated for credit. Prerequisite: consent of the instructor. (HU)

Courses Taught in English

MLL 73. (Asia 73) Fiction into Film: Modern Chinese Literature in Translation (4)
Students will discuss the narrative techniques used in 20th century Chinese fiction and film to reflect social issues such as the use of women as a medium of expression for male artists, the conflict between sexuality and nationalism, and the function of violence in art and revolution. This course will be project-based: students will be broken up into groups which are responsible for making presentations on readings and films assigned either to the class as a whole or just to the group. (HU)

MLL 74. (Asia 74) Chinese Cultural Program (1-8)
A summer program in China, taught in English. (HU)
Study of the major writers of the period, including Ronsard.

Fren 223. Love and the French Novel (4)
Representative works from each period of French literature from Tristram and Iseult and La Princesse de Cleves to Gide's L'Immoraliste. Style, themes, myths, and story patterns are analyzed. Wolfgang (HU)

Fren 271. Readings (4)
Study of the works of some author or group of authors, or of a period, or of a literary theme. May be repeated once for credit. (HU)

Fren 281. French Cultural Program (1-6)
A program in a French-speaking country offering formal language courses and cultural opportunities. (HU)

Fren 302. Medieval French Literature (4)
Introduction to Old French from La Chanson de Roland to Francois Villon. Wolfgang (HU)

Fren 303. Arthurian Romances (4)

Fren 306. Renaissance French Literature (4)
Study of the major writers of the period, including Ronsard, Rebelaus, and Montaigne. Wolfgang. (HU)

Fren 311. French Classicism (4)
French classical theater, novel, and criticism, with emphasis on Corneille, Racine, Moliere, Pascal, Lafayette, Malherbe, and Boileau. Chabut (HU)

Fren 313. The Age of Enlightenment (4)
The Philosophes and Encyclopedistes of the 18th century, with emphasis on Voltaire, Rousseau, Montesquieu, and Diderot. Chabut (HU)

Fren 316. Nineteenth Century Literature (4)
Study of major 19th century novelists and poets. (HU)

Fren 318. (Thtr 318) Drama in the Twentieth Century (4)
Contemporary French drama with an analysis of its origins and movements. Armstrong (HU)

Fren 319. Twentieth Century Novel and Poetry (4)
Detailed study of representative major works. Armstrong (HU)

Fren 320. Contemporary French Fiction (4)
Reading and discussion of contemporary works of fiction (post-1980). Study of how these works fit into the context of French literature and relate more specifically to major literary currents of the 20th century. Armstrong (HU)

Fren 321. Twentieth-Century French Short Fiction (4)
Examination, within the framework of short fiction (tales, short stories, and short novels), the major literary currents which have made up 20th century literature, exploring works by Camus, Cocteau, Gracq, de Mandiargues, Robbe-Gillet, Sarraute, and others. Instruction in French. Armstrong (HU)

Fren 327. (WS 327) Women Writing in French (4)
Reading and discussion of works written by women in French. The emphasis is on 19th- and 20th-century writers, such as G. Sand, Colette, S. de Beauvoir, M. Duras, and Andree Cheidid. Chabut (HU)

Fren 345. Advanced French for Business and Foreign Careers (4)
Understanding and writing French for business and international affairs. Readings and oral presentations of current interest, with technical vocabulary (marketing, finance, industry, agriculture, communications, transport, real estate, economic relations, environment, etc.) (HU)

Fren 369. Readings (4)
Advanced study of an author, period, or theme. Topics vary. May be repeated for one credit. (HU)

Fren 370. Internship (1-8)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in French-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. (HU)

Fren 371. Independent Study (1-8)
Special topics under faculty guidance, including honors thesis. May be repeated once for credit. Prerequisite: consent of instructor. (HU)

German

Undergraduate Courses in German

Germ 1. Elementary German I (4)
Fundamentals of German; reading and simple texts; simple conversation and composition; vocabulary building. Three class hours plus one laboratory or drill hour each week. No previous German required. (HU)

Germ 2. Elementary German II (4)
Continuation of Germ 1, including reading of more advanced texts. Three class hours plus one laboratory or drill hour each week. Prerequisite: Germ 1 or equivalent. (HU)

Germ 11. Intermediate German I (4)
Review of grammar, composition, reading of intermediate texts, vocabulary building. Prerequisite: Germ 2, or four units of entrance German or consent of instructor. (HU)

Germ 12. Intermediate German II (4)
Continuation of Germ 11. Prerequisite: Germ 11 or consent of instructor; one hour of lab. (HU)

Germ 81. German Cultural Program (1-8)
Summer program abroad. Formal instruction in the language and the culture of a German speaking country. (HU)

Germ 163. Introduction to German Culture (4)
Lectures, readings, and discussion of selected aspects of German culture. Prerequisite: German or consent of instructor; one hour of lab, video, or library, plus report. (HU)

Germ 165. Introduction to the German Literary Tradition (4)
Representative works from one or more of the major periods of German literature. Prerequisite: Germ 12 or equivalent, or consent of instructor; one hour of library plus written report. (HU)

Germ 167. Conversation and Composition (4)
Intensive practice in oral and written German. Prerequisite: Germ 12 or equivalent, or consent of instructor; one hour of oral video or library with written report. (HU)

Germ 169. Business German (4)
Introduction to German for business and foreign careers. Understanding, reading, writing, and speaking of German with an emphasis on technical vocabulary. Partial preparation for International Certificate of Business German. Prerequisite: Germ
Germ 201. Survey of German Literature I (4)
German literature to the second half of the 18th century. Readings, lectures, and discussion of representative works. (HU)

Germ 202. Survey of German Literature II (4)
From the Age of Goethe to the present. Readings, lectures, and discussion of representative works; one hour of library plus written report. (HU)

Germ 211. Introduction to German Drama (4)
Drama as a literary genre; plays from various periods of German literature; one hour of library tapes and written report. (HU)

Germ 218. (Thtr 218) Goethe’s “Faust” (4)
Study of Goethe’s play with an introduction to the Faust tradition; weekly paper on assigned topic. (HU)

Germ 231. New German Cinema (4)
Oral discussion and written analysis of selected films. (HU)

Germ 240. German in Daily Usage (4)
German as used in daily life. (HU)

Germ 241. Advanced Composition and Conversation (4)
Practice in writing and speaking in German; one hour of TV program or written research, with paper. (HU)

Germ 250. Special Topics (1-4)
Literary and linguistic topics not covered in regular courses. May be repeated for credit. (HU)

Germ 281. German Cultural Program (1-8)
Study abroad. Formal instruction in German and direct contact with the people and the culture during at least one month in a German-speaking country. Prerequisites: consent of German study abroad adviser. (HU)

Germ 301. Medieval German Literature (3)
Lectures and readings in medieval literature in translation. Introduction to Middle High German. (HU)

Germ 302. Renaissance, Reformation, and Baroque (4)
Writers and literary movements from the end of the Middle Ages through the Baroque; weekly research paper on topic. (HU)

Germ 303. German Romanticism (4)
Early and late romanticists; one hour of research paper, or lab films with paper. (HU)

Germ 305. 20th-Century German Literature (4)
Topics in German literature of the 20th century; weekly research paper. (HU)

Germ 315. Translation and Stylistics (4)
Translations from such areas as politics, business, and athletics. Stylistically correct German in professional letters, resumes, and academics. Understanding German in various regions of central Europe; paper on translation from newspaper or periodical. (HU)

Germ 320. Berlin in the Twenties (4)
Literature and culture of the Weimar Republic; paper from weekly library research. (HU)

Germ 325. 19th-Century German Literature (4)
Representative writers of post-Romanticism; weekly library research paper. (HU)

Germ 341. Advanced Phonetics, Linguistics, Composition, Conversation, and Translation (4)
Essay writing and translation from and into German; TV programs and paper on one segment. (HU)

Germ 344. The Age of Enlightenment and Classicism (4)
Selected works of the period; weekly paper from library research. (HU)

Germ 350. Special Topics (1-4)
Literary or linguistic topics not covered in regular courses. May be repeated for credit. Prerequisite: permission of the instructor. (HU)

Germ 370. Internship (1-8)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in German-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. Prerequisite: Germ 167 and/or approval of the staff in German. (HU)

Courses Taught in English
MII. 43. German Literature in Translation (4)
One period or theme in German literature. (HU)

Hebrew
The department offers courses both separately and in the context of the Jewish studies minor (Section III).

Hebr 1. Elementary Modern Hebrew I (4) fall
Classroom and laboratory instruction to develop hearing, speaking, reading, and writing the language. Cultural, ethnic, and religious dimensions of Israeli society. Tapes, textual materials, short stories. No previous study of Hebrew required. (HU)

Hebr 2. Elementary Modern Hebrew II (4) spring
Continuation of Hebrew I utilizing the audio-lingual approach. Fundamentals of the language, structure and sounds; the Hebrew verb; reading and vocalized stories; written exercises; tapes; short stories. Prerequisite: Hebr 1 or its equivalent. (HU)

Hebr 11. Intermediate Modern Hebrew I (4) fall
Classroom and laboratory instruction to develop fundamental patterns of conversation and grammar; composition, reading of texts, laboratory work and sight reading; comprehension, speaking, reading and writing of unvocalized materials. Prerequisite: Hebr 2 or qualifying examination. (HU)

Hebr 12. Intermediate Modern Hebrew II (4) spring
Continuation of Hebrew 11. Reading of texts, including selected short stories, outside reading and supplementary material; increased emphasis on oral presentation. Prerequisite: Hebr 11 or approval of the department chairperson.

Japanese
See Asian Studies major and minor.

Jpns 1. Elementary Japanese I (4) fall
Introduction to the oral and written language with emphasis on spoken Japanese and syllabaries. Language laboratory. (HU)

Jpns 2. Elementary Japanese II (4) spring
Continuation of Japanese 1. Prerequisite: Japanese 1 or equivalent. (HU)

Jpns 11. Intermediate Japanese I (4) fall
Continuation of Japanese 2. Structural patterns in both spoken and written languages. 150 kanji (Chinese characters). Prerequisite: Jpns 2 or equivalent. (HU)
Jpns 12. Intermediate Japanese II (4) spring
Continuation of Japanese I. Prerequisite: Japanese I or equivalent. (HU)

Jpns 141. Advanced Japanese I (4) fall
Advanced reading and oral comprehension. Conversation and writing practice. Prerequisite: Jpns 12 or equivalent. (HU)

Jpns 142. Advanced Japanese II (4) spring
Continuation of Jpns 141. Prerequisite: Jpns 141 or equivalent. (HU)

Jpns 290. Special Topics (1-4)
Literary or linguistics topics not covered in regular courses. May be repeated for credit. Prerequisite: consent of instructor. (HU)

Jpns 291. Advanced Japanese and Culture Abroad (1-8)
Japns 290. Special Topics (1-4)

Courses Taught in English

MLL 68. (Asia 68) Japanese Language: Past and Present (4)
Historical and contemporary aspects of the Japanese language, including the origins of Japanese in relation to Korean, the influence of Chinese, syntactic features which reflect the hierarchical character of Japanese society, differences in female and male speech, and use of foreign loan words. Prerequisite Jpns 1. (HU)

Russian

Russ 1. Elementary Russian I (4) fall
Classroom and laboratory, audio, and video introduction to the fundamentals of conversational and grammatical patterns; practice in pronunciation, simple conversation, reading, and writing. (HU)

Russ 2. Elementary Russian II (4) spring
Continuation of Russ 1. Prerequisite: Russ 1 or two years of entrance Russian. (HU)

Russ 11. Intermediate Russian I (4) fall
Classroom and laboratory practice in conversation. Development of reading and writing skills. Prerequisite: Russ 2 or three units of entrance Russian or equivalent. (HU)

Russ 12. Intermediate Russian II (4) spring
Continuation of Russ 11. Prerequisite: Russ 2 or 11, or equivalent. (HU)

Russ 141. Conversation and Composition I (4) fall
Intensive practice in oral and written Russian; laboratory practice in oral comprehension. Readings and discussions on Russian literature and culture. Prerequisite: Russ 12 or three units of entrance Russian. (HU)

Russ 142. Conversation and Composition II (4) spring
Continuation of Russ 141. Prerequisite: Russ 141. (HU)

Russ 198. Survey of Soviet Films (1-4)
Historical and social context; variable credit. (HU)

Russ 215. Russian Classics: Russian Literature with Variable Topic and Credit (3-4)
May be repeated for credit. (HU)

Russ 231. Russian in the Real World I (4)
Readings and conversations about selected nonliterary topics including the social and natural sciences, business, economics, the environment, current political events in Russia and throughout the former Soviet republics. (HU)

Russ 232. Russian in the Real World II (4)
A continuation of Russ 231. (HU)

Russ 251. Special Topics (4) fall
Intensive study of literary or linguistic topics. Prerequisite: Russ 142. May be repeated for credit. Nicholas (HU)

Russ 252. Special Topics (4) spring
Intensive study of literary or linguistic topics. Prerequisite: Russ 142 or 251. May be repeated for credit. Nicholas (HU)

Russ 370. Internship (1-8)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in Russian-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. Prerequisites: Russ 141 or 142 and approval of faculty committee on internship. (HU)

Russ 391. Special Topics (1-4)
Independent study of research under faculty guidance on a literary, linguistic, or methodological topic. May be repeated once for credit. May be used to satisfy the doctoral language requirement. Prerequisites: consent of instructor. Nicholas (HU)

Courses Taught in English

MLL 23. Lehigh in Russia (1-8)
A summer program in Russia, taught in English. (HU)

MLL 27. Russian Classics (4)
Russian classics in translation. May be repeated for credit. (HU)

MLL 349. (Hist 349) Cultural History of Medieval Russia (4)
Survey of medieval Russian history from the 11th to the late 17th centuries. Historical works on the period, early Russian epics, chronicles, legends, saints' lives, sermons, folk poetry, and Russian picaresque tales. Development of art and architecture. (HS)

Spanish

Undergraduate Courses in Spanish

Span 1. Elementary Spanish I (4) fall
Basic conversational Spanish illustrating essential grammatical principles. Reading of simple texts and writing. Lab required. (HU)

Span 2. Elementary Spanish II (4) spring
Continuation of Span 1. Prerequisite: Span 1 or equivalent. (HU)

Span 11. Intermediate Spanish I (4) fall
Limited review of elementary grammar concepts and introduction to more advanced grammar. Emphasis on discussion, reading, and writing about significant topics in the Spanish-speaking world. Students will be required to complete one hour of independent lab work, plus lab contact hour. Prerequisite: Span 2 or equivalent. (HU)

Span 12. Intermediate Spanish II (4) spring
Practice and application of previously learned grammar to give maximum exposure to Spanish in contemporary contexts. Materials include articles from current periodicals, video, and literature from Spain and Spanish America, plus lab contact hour. Prerequisite: Span 11 or equivalent. (HU)

Span 131. Communicating in Spanish for Medical Personnel (4)
For prospective medical personnel communicating with Spanish-speaking patients. Dialogues, health-care vocabulary. Review of grammar. Language laboratory practice, plus hospital intensive hour. Prerequisite: Span 12 or equivalent. Lefkowitz. (HU)
Span 133. Phonetics and Pronunciation (4)
Comparison of Spanish and English sounds; descriptions of Spanish vowels and consonants in their various positions. Oral practice in language laboratory. Special emphasis on accent and intonation patterns. Prerequisite: Span 2. Staff (HU)

Span 141. Advanced Grammar (4) fall
Intensive review of Spanish grammar with stress on finer points. Students may choose an optional fourth independent hour for improving grammar through writing, plus writing lab/cooperative learning hour. Prerequisite: Span 12 or equivalent. Staff (HU)

Span 142. Advanced Conversational Spanish (4) spring
Conversational practice stressing the building of vocabulary based on literary texts and topics of general interest. Designed to stimulate fluent and spontaneous use of spoken Spanish. Enrollment limited to 15. Prerequisite: Span 141 or equivalent. Staff (HU)

Span 151. Cultural Evolution in Spain (4) fall
The historical and cultural evolution of Spain. Discussion of major literary works in their cultural and historical contexts. Prerequisite: Span 141 or 142 or consent of instructor; two 2-hour sessions. Lefkowitz (HU)

Span 152. Cultural Evolution of Latin America (4)
The historical and cultural evolution of Latin America. Discussion of representative literary works in their cultural and historical contexts; two 2-hour sessions. Prerequisite: Span 141, 142, or consent of instructor. Prieto or O'Bryan (HU)

Span 199. Special Topics (3-4)
For students who take a course, not offered at Lehigh, at another institution. May be repeated once for credit. Prerequisite: approval of faculty. (HU)

For Advanced Undergraduates and Graduate Students
Span 211. Practical Business Spanish (4)
For students with a basic knowledge of Spanish: the language in business, law, international and social relations. Letter writing, comprehension of technical texts, specialized professional vocabulary and review of grammar. Prerequisite: Span 141 or equivalent. Staff (HU)

Span 212. Writing Skills (4)
Improving writing proficiency through practice in composition and translation. Prerequisite: Span 141 or equivalent, plus independent writing hour. Staff (HU)

Span 231. Spanish American Literature (4)
Literature of the pre-Columbian, conquest, and colonial periods. Oral and written reports; two 2-hour sessions. Prerequisite: Span 151 or 152. (HU)

Span 263. The Spanish American Short Story (4)
Comparative study of the literary problems posed by the work of significant short story writers such as Quiroga, Borges, Cortazar, Ribeyro, and others. Prerequisite: Span 152. Prieto or O'Bryan (HU)

Span 265. Spanish and Latin American Cinema (4) fall
Oral discussion and written analysis of selected films; three contact hours and two lab hours. Prerequisite: Span 142 or equivalent. (HU)

Span 297. Special Topics (2-4)
Study of an author or theme, or completion of a special project. Topics vary. May be repeated once for credit. Prerequisites: Span 151 or 152 or permission of the instructor. Staff (HU)

Span 303. Don Quixote (4)
Reading and critical analysis; two 2-hour sessions. Prerequisite: Span 151. Lefkowitz (HU)

Span 305. Spanish Literature of the Middle Ages (4)
Reading and discussion of outstanding works such as El Cid, El Liru de Buen Amor and La Celestina. Topics vary. Prerequisite: Span 151. Lefkowitz (HU)

Span 308. The Spanish Novel Since 1939 (4)
The evolution of the novel from post-civil war to the present. Reading of Cela, Laforet, Delibes, Rodoreda, and Marse, among others. Prerequisite: Span 151 or permission of the instructor. (HU)

Span 320. Literature of the Spanish Caribbean (4)
Study of representative works with emphasis on Cuba and Puerto Rico. Writers include Barnet, Carpentier, Sanchez, and Rodriguez Julia. Prerequisite: Span 152. Prieto (HU)

Span 321. Children and Adolescents in Contemporary Spanish American Literature (4)
Discussion of narrative techniques and the category of the self as they relate to the images of adolescence and childhood in works by such authors as Vargas Llosa, Reinaldo Arenas, Jose Bianco, Silvinia Ocampo. Prerequisite: Span 152. Prieto (HU)

Span 322. The Short Novel in Contemporary Spanish American Literature (4)
Reading and discussion of representative works by Garcia Marquez, Onetti, Rulfo, Bioy Casares, and others. Prerequisite: Span 152. Prieto or O'Bryan (HU)

Span 323. Literature and Revolution in Contemporary Cuba (4)
Study of works written after 1959 by dissident, non-dissident, and exiled authors (Desnoes, Norberto Fuentes, Benitez Rojo, Cabrera Infante). Discussion of problems raised by the social function of intellectuals and of literature as they relate to themes, modes of writing, genres. Prerequisite: Span 152. Prieto (HU)

Span 325. Hispanic Literature of the United States (4)
Discussion of fiction, poetry, drama, and film from the main groups in the U.S. Hispanic population. Discussion of Hispanic ethnic identity, bilingualism, and minority issues. Prerequisite: Span 152. Prieto (HU)

Span 342. The New Narrative in Spanish American Literature (4)
Critical evaluation of distinguished works of Spanish American prose fiction of the 1960's and 70's. Readings by Donoso, Fuentes, Garcia Marquez, and Vargas Llosa, among others. Prerequisite: Span 152 or permission of the instructor. (HU)

Span 379. Internship (2-4)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in Spanish-speaking countries or agencies serving the Hispanic community. Assigned readings, written reports, and employer performance evaluations are required. Prerequisites: Span 141 or 142 and approval of faculty. (HU)

Span 397. Special Topics (2-4)
Study of an author, theme or period. Topics vary. May be repeated once for credit. Prerequisites: Span 151 or 152 and permission of the instructor. Staff (HU)

Courses Taught in English
M.I.L. 51. Contemporary Hispanic-American Literature (4)
Reading and discussion of distinguished Latin American writers: Borges, Garcia Marquez, Cortazar, and Vargas Llosa. (HU)
Significant literary dialogue between writers of the United States and Spanish America, including Borges, Dos Passos, Morrison, Faulkner, Garcia Marquez, Neruda, Poe, Whitman, and Vargas Llosa, among others. (HU)

Music

Professors. Paul Salerni, Ph.D. (Harvard); Steven Saimetz, D.M.A. (Wisconsin); Nadine Sine, Ph.D. (N.Y.U.); Chair Assistant Professor. Paul Chou, M.M. (SUNY - Stony Brook)
Lecturers. William Warwick, M.M. (Manhattan); Eugene Albusescu, M.M. (Indiana)
Adjunct Professors. Debra Field, B.M.E. (U. Houston); HeeYoun Kim, M.M. (Northwestern); Vincent Metalle, M.M. (Westminster Choir College); Richard Metzger, M.M. (Marywood); Albert Neumeyer, M.M. (Trenton); Laura Johnson, M.F.A. (Boston University); Grisha Alexiev, A.D. (New England Conservatory); Paul LaFollette, B.M. (Curtis Institute of Music).
Private Instructors. Bass: Peter Paulsen; Boassoon: Stephen Wisner; Clarinet: Chris Di Santo; Flute: Robin Kani, Linda Ganus; French Horn: Paul LaFollette; Guitar: Richard Metzger (acoustic), Tom Kozic (electric), Vic Juris (electric); Harp: Andrea Witchen; Oboe: David Diggs; Organ: Tim Harrell; Piano: Eugene Albusescu, Helen Beedle, HeeYoun Kim, Tim Harrison (jazz), Wendy McNally, Pat O'Connell, Debra Torok; Percussion: Grisha Alexiev; Saxophone: Mark Hulsebos, Dave Reikneg; Trombone and Tuba: John Ilka; Trumpet: Bill Warfield (jazz), Lawrence Wright; Viola and Violin: Paul Chou, Amy Martin; Violincello: Nancy Bidlack, Carrie Cimidoro; Voice: Debra Field, Vincent Metalle, Carolyn Smith, Jennifer Albusescu.

The study of music can develop skills which will serve the student well in any career: self-discipline, teamwork, problem solving and leadership. A student graduating with the BA degree in music will have a strong foundation in music theory and substantial exposure to western music from the Middle Ages to the present. This curriculum will prepare a student for graduate studies in musicology, music theory, or composition. A music major or minor taken in conjunction with a business major may lead to a variety of careers in arts management or in the recording and music publishing industries. For some a double major or a minor in music will not lead to a career but to a life-long involvement with an art form that gives lasting satisfaction.

The music department offers courses in music history, literature, theory, composition, musicianship, in addition to significant performance experiences in instrumental and vocal ensembles, large and small, and in private instruction. The Zoeller Arts Center facilities include a Listening Library, practice rooms, a composition studio, a digital class piano room, an ear-training room, a fine recording studio, classrooms and rehearsal rooms. Most importantly, the center boasts its concert facility, Baker Hall; with its 1000-seat capacity and excellent acoustics, it is flexible both on the stage (concert or theater mode) and in seating arrangements. The fully adjustable pit can serve opera or musical theatre, as additional seating, or it can become an extension of the stage.

Major program. The music major may choose between three different concentrations: performance; history and literature; and theory and composition. Many students choose music as a second major; this program provides a substantial musical foundation for those who might choose a related field (e.g., arts management, part-time performance careers in orchestras) or who simply want a concentrated exposure to music study. For those who intend to pursue graduate study in music or a performing career, the major program should be viewed as the minimum requirement. Such students should regularly seek the advice of department faculty in expanding their program to suit their particular needs and goals.

Performance concentration. Thirteen credits in theory and musicianship skills: Mus 11, 2, 82, 3, 7, 83, 4, 8. Nine credits of music history (any 3 from Mus 233, 234, 235, 236) and eleven credits in lessons, ensembles and recitals. The student must perform a half recital in the junior year, a full recital in the senior year, and juries during the sophomore and junior years. 33-credit minimum.

History concentration. Thirteen credits in theory and musicianship skills: Mus 11, 2, 82, 3, 7, 83, 4, 8. Twelve credits of music history (Mus 233, 234, 235, 236) and eight credits in electives, lessons, and ensembles, of which at least three must be in performance. The student must produce a major research paper during the senior year and prepare program notes for department concerts during at least one semester. 33-credit minimum.

Composition and theory concentration. Twenty-one credits in theory: Mus 11, 2, 82, 3, 7, 83, 4, 8, 243, 245. Six credits of music history (any 3 from Mus 233, 234, 235, 236) and six in composition (Mus 253, 254), plus three in lessons or ensembles. Students must produce a substantial composition or theoretical analysis under the direction of department faculty during the senior year. 36-credit minimum, though many students will be able to test out of keyboard skills.

Minor program. The minor requires a minimum of 17 credits and may include Mus 80 and 90. The program is designed to be flexible but must include Mus 11, 2, 82, 3, and 7, one history or literature course, and two performance courses (Mus 22-79). The student may choose the remaining six credits from department offerings, including up to three additional performance or musicianship courses.

Concert Requirement. Each semester majors and minors must attend three concerts approved by the music department. (Music 100)

Departmental Honors. A student must have a 3.5 average in courses in the major to pursue honors. Candidates for departmental honors should submit to the department chair a written proposal, prepared in consultation with a faculty project adviser by the end of the junior year. The project could result in a research paper, a composition or a performance. Upon acceptance of the proposal by the department faculty, the student should register for Mus 350 for one to six credits, which may be taken all at once or over the senior year. The awarding of departmental honors will be contingent on the quality of the completed project.

Private lessons. Lessons in a wide variety of instruments and voice may be taken for one credit. They must be arranged through the department at set fees that are not included in tuition. Please note that pre-registering for lessons cannot guarantee availability due to difficulties in scheduling.

Performing groups. Admission to band, choir, ensembles, and orchestra is by audition, and students receive one credit per semester by registering for the appropriate course number. Although there is no limit to the number of courses in this series that may be taken, students should check with their advisor to determine the number that may be applied toward graduation.

Most department performances take place in Baker Hall, a 1,000-seat theatre in the new Zoeller Arts Center. In cooperation with the center, the department co-sponsors a variety of guest artists, many of whom offer master classes to music students.

Course Offerings

Please note that many upper level courses have no prerequisites beyond Mus 10 or 80 and are open to anyone with basic knowledge of musical terminology.
Mus 1. Listening to Music (1) fall-spring
Issues relating to hearing live music, introduction to basic musical terms and genres. Attendance at ten approved concerts with brief written reviews. (ND)

Mus 2. Keyboard Skills I (1) spring
Beginning piano skills designed to enable the student to use the piano as a tool. Major and minor scales in both hands, forming chords, elementary sight reading. Students may test out upon examination. (HU)

Mus 3. Keyboard Skills II (1) fall
Continuation of Mus 2. Diatonic progressions in major and minor; more advanced sight reading. Students may test out upon examination. Prerequisite: Mus 2. (HU)

Mus 4. Keyboard Skills III (1) spring
Additional keyboard skills, including progressions with secondary chords, modulations, and sight reading. Students may test out upon examination. Prerequisite: Mus 3 (HU)

Mus 7. Aural Skills (1) fall
Sight singing and ear training through dictation exercises. Rhythm exercises. Prerequisite: Mus 10 or 11 or equivalent (HU)

Mus 8. Aural Skills II (1) spring
Continuation of Mus 7. Prerequisite: Mus 7. (HU)

Mus 10. Basic Skills in Music (2) fall
Rudiments of musical notation, beginning skills in sight singing, ear training, rhythm and keyboard. Intended for anyone who does not plan to major or minor. (HU)

Mus 11. Basic Musicianship (2) spring
Development of basic skills in using notation, sight singing and ear training. For intended majors or minors. Should be taken with Mus 2. (HU)

Mus 21-29. Applied music and performance courses may be repeated for graduation credit up to eight times in the CAS, six times in CEAS and CBE. Prerequisite: Admission to Music 22-62 by audition. Music 68, 71-79 have fees.

Mus 21. Marching Band (1) fall. (ND)
Mus 22. Wind Ensemble (1) fall-spring (HU)
Mus 23. Symphonic Band (1) spring (HU)
Mus 24. Jazz Ensemble (1) fall-spring (HU)
Mus 25. Jazz Band (1) fall-spring (HU)
Mus 31. University Choir (1) fall-spring (HU)
Mus 32. Choral Union (1) fall-spring (HU)
Mus 33. Overtones (1) fall-spring. Co-requisite: Mus 31 (HU)
Mus 37. Scenes from Opera and Musical Theatre (1) fall-spring (HU)
Mus 48. Chamber Music Collegium (1) fall-spring (HU)
Mus 51. L.U.V.M.E (1) fall-spring (HU)
Mus 61. Lehigh University Philharmonic (1) fall-spring (HU)
Mus 62. Chamber Orchestra (1) fall-spring (HU)
Mus 68. Class Piano for Beginners (1) fall-spring (HU)
Instruction for beginning piano students, including rudiments of musical notation in relation to the keyboard; beginning pieces for solo piano and the group.

Mus 70. Recital (1-2) fall-spring. Department permission (HU)
Mus 71. Private Piano Study (1) fall-spring (HU)
Mus 72. Private Vocal Study (1) fall-spring (HU)
Mus 73. Private String Study (1) fall-spring (HU)
Mus 74. Private Woodwind Study (1) fall-spring (HU)
Mus 75. Private Brass Study (1) fall-spring (HU)
Mus 76. Private Percussion Study (1) fall-spring (HU)
Mus 77. Private Organ Study (1) fall-spring (HU)
Mus 78. Private Acoustic Guitar Study (1) fall-spring (HU)
Mus 79. Private Electric Guitar Study (1) fall-spring (HU)
Mus 80. Masterpieces of Music (3) fall or spring
Listening skills and awareness of musical styles in Western music developed through study of recognized masterpieces. (HU)

Mus 82. Harmony I (3) fall
Exercises in writing in four-part chorale style. Music 3 and 7 must be taken concurrently. Prerequisites: Mus 11 and 2 or equivalent. (HU)

Mus 83. Harmony II (3) spring
Continuation of Music 82 including modulation, non-harmonic tones, analysis. Music 4 and 8 must be taken concurrently. Prerequisites: Mus 82, 3, and 7 or equivalent. (HU)

Mus 100. Concert Requirement (0) fall, spring
Concerts approved by the department (for majors and minors)

Mus 128. Jazz History I (3) fall
A study of the roots of jazz. Starting in West Africa, the course traces the synthesis of African and European elements of 1945. Musicians covered are Gottshalk, Bolden, Morton, Armstrong, Hawkins, Basie, Ellington, etc. Can be taken independently of Jazz History I, but the first course would be helpful. Prerequisite: Mus 10 or 80, or equivalent. (HU)

Mus 129. Jazz History II (3) spring
A survey of modern jazz from 1945 to the present. Musicians covered are Parker, Gillespie, Monk, Davis, Coltrane, Hancock, and Coleman. Can be taken independently of Jazz History I, but the first course would be helpful. Prerequisite: Mus 10 or 80, or equivalent. (HU)

Mus 131. Major Genre (3) fall or spring
History and analysis of music of a particular type: Opera, oratorio, symphony, etc. May be repeated for credit as title varies. Prerequisite: Mus 10 or 80 or equivalent. (HU)

Mus 132. Composer and Era (3) fall or spring
Life and development of a composer’s style viewed in historical context. Title varies: Bach, Beethoven, Mozart, etc. May be repeated for credit as title varies. Prerequisite: Mus 10 or 80 or equivalent. (HU)

Mus 233. Medieval and Renaissance Music (3) fall, odd
Development of musical style from early Christian chant to the sacred and secular forms of the late 16th century, viewed in cultural contexts. Prerequisite: Mus 11 or 80 or equivalent. Sine. (HU)

Mus 234. Baroque and Classical Music (3) spring, even
The major genres and composers of the 17th and 18th centuries studied in their cultural context. Prerequisite: Mus 11 or 80 or equivalent. Sine. (HU)

Mus 235. Romantic Music (3) fall, even
Study of the major composers and their works from late Beethoven to Mahler and Strauss. Prerequisite: Mus 11 or 80 or equivalent. Sine. (HU)

Mus 236. Twentieth-Century Music (3) spring, odd
Beginning with the major trends at the turn of the century, a study of the important composers and works of our century to the present. Prerequisite: Mus 11 or 80 or equivalent. Sine. (HU)

Mus 243. Counterpoint (4) fall
Writing and analyzing pieces in Renaissance and Baroque contrapuntal styles. Prerequisites: Mus 83, 4, and 8 or equivalent. Salernı (ND).

Mus 245. Classical and Romantic Forms (4) spring
Analyzing and writing pieces in classical and romantic forms. Exercises in chromatic harmony. Prerequisite: Mus 243 (ND)
Mus 251. Special Topics (1-3)
Study of musical topics in history or composition not covered in regular courses. May be repeated for credit as title varies. Prerequisite: consent of the department chair. (HU)

Mus 253. Composition I: Electronic and Acoustic Techniques (3) fall
Writing for acoustic and electronic instruments based on 20th-century models. Acoustic orchestration, digital synthesis, effects processing. Use of the computer for score preparation and as a compositional tool. Prerequisite: Mus 83, 4, and 8 or permission of instructor. Salerni. (ND)

Mus 254. Composition II (3) spring
Continuation of Mus 253. Prerequisite: 253. Salerni. (ND)

Mus 256. Recording Techniques I (3) fall
Recording music in various popular and classical styles using state of the art studio equipment. Topics include microphone choice, placement, mixing, effects processing, digital editing and post production. Prerequisites: Mus 82, 3, and 7 or permission of instructor. (ND)

Mus 257. Recording Techniques II (3) spring
Continuation of Recording Techniques I. Prerequisite: Mus 256. (ND)

Mus 291. Independent Study (1-3)
Individually supervised work in history or composition, or continuation of projects begun in regular courses. May be repeated for credit. Prerequisite: consent of department chair. (HU)

Mus 300. Apprentice Teaching (1-3) (ND)
Mus 350. Senior Project (1-6)

Natural Science
Paul B. Myers, Ph.D. (Lehigh), program director

This major program provides students with a broad background in the fundamentals of mathematics and science and the opportunity to concentrate to a reasonable extent in one area of science.

The program leads to a bachelor of arts degree and is designed especially for the following: 1. those students who want preparation for graduate work or careers in certain of the derivative or interdisciplinary sciences or related professional fields (oceanography, astronomy, psycho-physiology, medicine or dentistry, etc.); 2. those students who plan to teach in secondary schools or community colleges; and 3. those students without fixed career objectives who want undergraduate training in science.

Students who register for the program are required to select an area of concentration (or option) that must be approved by the dean of the College of Arts and Sciences and the director of the program. The option may be chosen in chemistry, biology, geology, psychology, or in an approved interdisciplinary area (biophysics, marine science, biochemistry, computer science, etc.). Courses included in the option are worked out individually for the student by the major adviser.

Qualified students may be given permission at the end of the junior year to enter a program whereby they are able to begin work toward a graduate degree (master of arts, master of science, or master of education) during the senior year. Students enrolled in this program often complete all course requirements for the master’s degree with one year of study beyond the bachelor’s degree.

required preliminary courses
Math 21, 22, 23 Analytic Geometry and Calculus I, II and III (12)
Phy 11, 12 Introductory Physics I and Laboratory I (5)
Phy 21, 22 Introductory Physics II and Laboratory II (5) or
Phy 13, 14 General Physics and Laboratory (4)
Chm 21, 22 Introductory Chemical Principles and Laboratory (5)
EES 21 Introduction to Earth Materials and Processes (4) or
Astr I The Solar System (3)
EES 31 Introduction to Environmental and Organismal Biology
Psyc 1 Introduction to Psychology (3)

required major courses
Chm 51, 52 Organic Chemistry I, II (3,3) and
Chm 53, 58 Organic Chemistry Laboratory I, II (1,1) or
Chm 31 Chemical Equilibria in Aqueous Systems (3) and
Chm 187 Physical Chemistry I (3)
Math elective (3) or
Option (24) Note: The mathematics elective and courses included in the option are taken with approval of the major adviser.

Students registered for this major normally are expected to choose their option no later than the second semester of the sophomore year.

Philosophy

Professors. Mark H. Bickhard, Ph.D. (Chicago), Henry R. Luce Professor in Cognitive Robotics and the Philosophy of Knowledge; Steven Louis Goldman, Ph.D. (Boston), Andrew W. Mellon Distinguished Professor in the Humanities; Joan Straumanis, Ph.D. (Maryland).

Associate Professors. Gordon Bear, Ph.D. (Yale), chair, and William Wilson Selfridge Professor of Philosophy; Robin Dillon, Ph.D. (Pittsburgh); Roslyn Weiss, Ph.D. (Columbia), Clara H. Stewardson Professor of Philosophy.

Assistant Professors. Alexander Levine, Ph.D. (San Diego); Michael Mendelson, Ph.D. (San Diego).

Philosophy is born of discomfort. Whether it is the need to account for the tragedies of circumstance, the incongruities between our assumptions about the world and what experience and science reveal, or the shock of being exposed to hitherto unforeseen conceptual alternatives, philosophy arises in those contexts in which serious questions emerge about the adequacy of our most cherished beliefs.

Philosophy is driven by the unsettling awareness that we are not beings who act exclusively on instinct but are instead able to choose from among a variety of ways of thinking about ourselves, the world in which we find ourselves, and our relations with others. Moreover, the beliefs we hold are not merely incidental facts about us like height or eye color. What we believe is often central to our moral identity, the nature of our personal relationships, the manner in which we regard ourselves and treat others, and the happiness and unhappiness that form the emotional contours of our practical lives.

Philosophy is born out of our awareness that despite the centrality of our beliefs to our identity as moral beings, the truth of our beliefs can be uncertain, for on virtually any topic there is a variety of possible viewpoints, not all of which can be equally adequate.

In its attempt to ground our beliefs and justify them, philosophy becomes a reflective and critical conceptual activity concerned with foundational questions regarding our deepest assumptions and intuitions about the nature and extent of human knowledge (epistemology), about the nature of reality and
The major in philosophy consists of courses (37 credits) about the nature, scope, and grounds of moral value (ethics), and about the nature and theoretical foundations of formal reasoning and valid inference (logic).

The major program in philosophy is designed to provide a broad exposure to all of these areas as well as a strong grounding in the history of the western philosophical tradition. The program emphasizes the close reading and critical evaluation of classic texts from ancient times to the present, and students can expect to develop sophisticated analytic and expository skills that will enable them to engage in original, critical reflection on their own. To this end, the major program involves a combination of required and elective coursework as well as the opportunity to develop and pursue individual interests under faculty supervision. In addition to its regular course offerings, the department also sponsors a variety of activities (e.g. the annual Selfridge Lecture, the Philosophy Forum, the Faculty Seminar, the Philosophy Club, and the annual Reading Party), all of which are designed to complement the course offerings and to promote a university-wide philosophical community.

The major program provides excellent preparation for graduate study in philosophy as well as a solid foundation for any career that places a premium upon clear, careful thinking and rigorous conceptual and expository skills.

For additional information about the faculty, frequency of course offerings, and departmental events, please contact the department for a copy of its brochure.

The Minor Program
The minor in philosophy consists of four courses. The courses must include at least one course at the 200-level or above. Minor programs are planned in conjunction with the departmental advisor who will help the student plan a program compatible with his or her interests. Minor programs may be, but do not have to be, focused in a particular area such as ethics or the history of philosophy or philosophy of mind.

The Major Program
The major in philosophy consists of ten courses (37 credits) planned in conjunction with the student's major advisor. There are six required courses including a two-semester (6 credit) Senior Thesis, and four electives, of which three must be at the 200-level or above.

REQUIRED COURSES
Phil 114 Fundamentals of Logic
Phil 105 Ethics
Phil 131 Ancient Philosophy
Phil 135 Modern Philosophy
Phil 390 Senior Thesis
Phil 391 Senior Thesis

ELECTIVES
Four elective courses, of which three must be at the 200-level or above.

The Senior Thesis (Phil 390-1) is a year-long, independent project during which philosophy majors, with the consent and under the guidance of a faculty sponsor, investigate a topic of special interest to them. The topic may be historical or non-historical, pure or applied, interdisciplinary or disciplinary; the only constraint is that the student secure the cooperation of a faculty sponsor. During the fall (Phil 390), the student's energies will be devoted to refining the topic under investigation, working through the bulk of the essential literature, and producing a paper roughly 20 pages in length. During the spring semester (Phil 391), the student will investigate the same topic more intensively, expanding, revising, and refining the fall paper into a substantial senior thesis roughly 50 pages in length.

Honors
Departmental honors are awarded to philosophy majors if they satisfy two criteria: (a) at the time of graduation, their cumulative average in philosophy is 3.25 or better, and (b) they have successfully defended their senior thesis at an oral examination conducted by the philosophy faculty. Although every senior major will write a senior thesis, only those seniors whose progress in completing their thesis suggests they will pass such an examination will be invited to submit their thesis for honors in philosophy.

Undergraduate Courses
Phil 1. The Examined Life: An Introduction to Philosophy (4)
What makes a life meaningful, what makes it worth living? In pursuit of an answer to this question this course examines many of the basic questions of philosophy: ethical questions about justice and virtue, epistemological questions about the limits of human knowledge, metaphysical questions about what there is. (HU)

Phil 3. (Rel 3) Religion and Ethics in Religious Traditions (4)
Introduction to philosophical and religious modes of moral thinking, with consideration given to ethics in the world religions traditions (family life and role of women, social justice, environment, work, models of ethical ideals). Particular issues examined include abortion, corporal punishment (such as the death penalty), problems in medical ethics, and heavy drinking as a behavioral problem. (HU)

Phil 7. Introduction to Scientific Reasoning (4)
Introduction to informal deductive logic, inductive logic, and basic statistical inference. Emphasis is on the employment of these tools in everyday contexts: in weighing legal evidence, interpreting public opinion polls, and deciphering medical research. Assignments include daily newspaper readings. (HU)

Phil 102. (PolS 102) Modern Political Heritage (4)
Begins where PolS 101 ends; from early modern theorists (e.g. Hobbes) up to contemporary thinkers (e.g. Marcuse). (SS)

Phil 105. Ethics (4)
Examination of right and wrong, good and bad, from classic sources such as Plato, Aristotle, Hume, Kant, Mill and Nietzsche. (HU)

Phil 114. Fundamentals of Logic (3)
Introduction to formal deductive logic, involving the construction of logical proofs in a system of natural deduction with some attention to the philosophy of logic. (MA)

Phil 116. Bioethics (4)
Moral issues that arise in the context of health care and related biomedical fields in the United States today, examined in the light of the nature and foundation of moral rights and obligations. Topics include: confidentiality, informed consent, euthanasia, medical research and experimentation, genetics, the distribution of health care, etc. (HU)

Phil 121. Philosophy in Literature (4)
Exploration of philosophical themes through the study of literature and film. Authors may include: Homer, Euripides, Dante, Rimbaud, Sterne, George Eliot, Valery, Joyce, Melville, T.S. Eliot, Rilke, Proust, Musil, Stevens, Cummings, Camus, Sartre, Beckett, Morrison, Barthelme. (HU)

Phil 122. Philosophy of Law (4)
Analysis of the conceptual foundations of our legal system. Special attention devoted to the nature of law and legal obligation, liberty
and privacy in constitutional litigation, justice and contractual obligation, theories of punishment in criminal law, and the nature and scope of responsibility in criminal law. (HU)

Phil 123. Aesthetics (4)
Theories, classical and modern, of the nature of beauty and the aesthetic experience. Practical criticism of some works of art, and examination of analogies between arts, and between art and nature. (HU)

Phil 124. (Rel 124) Reason and Religious Experience (4)
Critical examination, from a philosophical perspective, of some fundamental problems of religion, the nature of religious experience and belief, reason and revelation, the existence and nature of God, the problem of evil, and religious truth. (HU)

Phil 127. Existentialism (4)
Investigation of the historical development of existentialism from its origins in the 19th century (Kierkegaard, Nietzsche) through its marriage to phenomenology in the early 20th (Heidegger, Sartre, Merleau-Ponty), and out the other side as a vigorous dimension of much literary, psychological, and artistic work produced in the last 50 years. (HU)

Phil 128. Philosophy of Science (4)
Introduction to the structure and methods of scientific investigation. The nature of explanation, confirmation, and falsification. Scientific progress: What is it? Would it be suffocated by obedience to completely rational methods? (HU)

Phil 129. (Rel 129) Jewish Philosophy (4)
Consideration of how major Jewish thinkers from the first to 20th centuries confronted questions at the intersection of religion and philosophy: the existence and nature of God, free will, evil, divine providence, miracles, creation, revelation, and religious obligation. (HU)

Phil 131. (Clss 131) Ancient Philosophy (4)
Historical survey of selected texts and issues in the classical world, from the pre-Socratics through Aristotle, with emphasis on the origins of the western philosophical traditions in ethics, metaphysics, and epistemology. (HU)

Phil 132. (Clss 132) Hellenistic Philosophy (4)
Historical survey of selected texts and issues in Post-Aristotelian Greek and Roman philosophy from the fourth century B.C. to the third century A.D. Areas of focus may include epicureanism, stoicism, academic and pyrrhonian skepticism, and neoplatonism. (HU)

Phil 133. Medieval Philosophy (4)
Historical survey of selected texts and issues in western philosophy from the fourth to 14th centuries. Attention will be given to the relation between developments in medieval philosophy and major currents in ancient and modern thought. Figures may include Augustine, Erigena, Anselm, Aquinas, Ockham, and Nicholas of Autrecourt. (HU)

Phil 135. Modern Philosophy (4)
Historical survey of selected texts and issues in 17th and 18th century European philosophy with particular emphasis on developments in epistemology and metaphysics. Attention will be given to the relation of the “modern period” to developments in late medieval philosophy and the rise of the experimental sciences. Figures may include Descartes, Leibniz, Locke, Hume, and Kant. (HU)

Phil 139. Contemporary Philosophy (4)
Philosophical thought from the late-19th century to the present; pragmatism, linguistic analysis, existentialism, and Marxism. Truth and knowledge, values and moral judgement, meaning, the place of the individual in the physical world and society, and the impact of the scientific method upon all of these. (HU)

Phil 140. (Asian Studies 140) Eastern Philosophy (4)
Survey of selected texts and issues in the eastern philosophical traditions. Attention will be given to the development and interrelations of these traditions as well as a comparison of western and eastern treatments of selected issues. Areas of focus may include Confucianism, Taoism, and Zen Buddhism. (HU)

Phil 205. Contemporary Ethics (4)
Examination of significant questions addressed by contemporary moral philosophers. Topics vary, but might include: What is a good person? Can a woman be good in the same way as a man? Is morality relative or absolute? Is morality all that important? Prerequisite: Phil 105 or consent of the instructor. (HU)

Phil 220. Knowledge and Justification (4)
Recent work in epistemology. Questions addressed include: If you don’t know whether you are dreaming, how can you know you have two hands? Does knowledge require answers to all possible doubts or only all reasonable doubts? How should we determine the horizon of the reasonable—psychologically or philosophically? (HU)

Phil 224. (Rel 224) Topics in the Philosophy of Religion (4)
Selected problems and issues in the philosophy of religion. Content varies. May be repeated more than once for credit. (HU)

Phil 226. (WS 226) Feminism and Philosophy (4)
Analysis of the nature, sources, and consequences of the oppression and exploitation of women and justification of strategies for liberation. Topics include women’s nature and human nature, sexism, femininity, sexuality, reproduction, mothering. Prerequisite: At least one previous course in philosophy or women’s studies. (HU)

Phil 228. Topics in the Philosophy of Science (4)
Themes in the natural, life and social sciences. May be repeated for credit as topic varies. Prerequisite: Phil 128 or consent of the department chair. (HU)

Phil 231. (Clss 231) Figures/Themes in Ancient Philosophy (4)
This seminar course will involve in-depth focus upon a major ancient thinker (e.g. Plato, Aristotle, Sextus Empiricus, Plotinus, etc.) or the classical treatment of a particular theme (e.g. “human nature,” “the good life,” ethical or political theory, etc.). Content varies. May be repeated more than once for credit. (HU)

Phil 233. Figures/Themes in Medieval Philosophy (4)
This seminar course will involve in-depth focus upon a major medieval thinker (e.g. Augustine, Boethius, Maimonides, Bonaventure, Dante, etc.) or the medieval treatment of a particular theme (e.g. the relation of “will” and “intellect,” the “problem of universals,” ethical or political theory, etc.). Content varies. May be repeated more than once for credit. (HU)

Phil 235. Figures/Themes in Modern Philosophy (4)
This seminar course will involve in-depth focus upon a major 17th or 18th century thinker (e.g. Descartes, Leibniz, Berkeley, Kant, etc.) or the modern treatment of a particular theme (e.g. the nature of “ideas,” the roles of experience, reason, and revelation, ethical or political theory, etc.). Content varies. May be repeated more than once for credit. (HU)

Phil 237. Figures/Themes in Nineteenth Century Philosophy (4)
This seminar course will involve in-depth focus upon a major 19th century thinker (e.g. Hegel, Marx, Kierkegaard, Mill, Peirce, Frege, Nietzsche, James, etc.) or the 19th century treatment of a particular theme (e.g. the end of history, revolution, nihilism,
This seminar course will involve in-depth focus upon a major contemporary thinker (e.g. Russell, Whitehead, Husserl, Heidegger, Wittgenstein, Quine, Habermas, Rawls, Rorty, Derrida, Davidson, Foucault, Deleuze, Irigaray, etc.) or the contemporary treatment of a particular theme (e.g. logical positivism, naturalism, non-foundationalism, existential phenomenology, return to virtue, neo-pragmatism, hermeneutics, post-structuralism, post-modernism, neo-kaantian political theory, the politics of identity, etc.). Content varies. May be repeated more than once for credit. (HU)

Phil 239. Figures/Themes in Contemporary Philosophy (4)
This seminar course will involve in-depth focus upon a major contemporary thinker (e.g. Russell, Whitehead, Husserl, Heidegger, Wittgenstein, Quine, Habermas, Rawls, Rorty, Derrida, Davidson, Foucault, Deleuze, Irigaray, etc.) or the contemporary treatment of a particular theme (e.g. logical positivism, naturalism, non-foundationalism, existential phenomenology, return to virtue, neo-pragmatism, hermeneutics, post-structuralism, post-modernism, neo-kaantian political theory, the politics of identity, etc.). Content varies. May be repeated more than once for credit. (HU)

Phil 250. The Minds of Robots and Other People (4)
Is the nature of thinking illuminated by what computers can do? Is the brain just a complex computer? Could a robot feel pain? Be angry? Recent work in artificial intelligence, psychology, and philosophy. (HU)

Phil 260. Philosophy of Language (4)
Analysis of the nature of the correspondence between the words we use and the world in which we live. Our unifying theme is the quest for an understanding of truth, conceived as a peculiar relation between language and reality. We examine such central notions as meaning and reference, as understood in historically influential philosophical theories of language. (HU)

Phil 264. (POLS 264) Issues in Contemporary Political Philosophy (4)
Selected topics in contemporary political philosophy, such as the Frankfurt school, existentialism, legitimation, authenticity, participatory democracy, and the alleged decline of political philosophy. May be repeated for credit with consent of the political science chair. (SS)

Phil 265. Philosophy of Mathematics (4)
Survey of metaphysical and epistemological issues from the philosophy of mathematics, with emphasis on the arguments on behalf of mathematical platonism, conventionalism, and psychologism. It is highly recommended that students take Phil 114 and a year of calculus, or otherwise acquire comparable formal background, prior to this course. (HU)

Phil 267. (POLS 267) American Political Thought (4)
Critical examination of American political thought from the founding of the Republic to the present. Writings from Madison, Hamilton, and Jefferson to Emma Goldman, Mary Daly, Malcolm X, Henry Kariel, and others will be discussed. (SS)

Phil 290. Independent Study (1-4)
Individual philosophical investigation of an author, book, or topic designed in collaboration with a faculty sponsor. Tutorial meetings; substantial written work. May be repeated more than once for credit. Consent of faculty sponsor required. (ND)

Phil 303. (Math 303) Mathematical Logic (3-4)
A course, on a mathematically mature level, designed not only to acquaint the student with logical techniques used in mathematics but also to present symbolic logic as an important adjunct to the study of the foundations of mathematics. Prerequisite for non-math majors: Phil 114 (MA)

Phil 390. Senior Thesis (2)
The first part of two semesters of intensive research and writing guided by a faculty sponsor in anticipation of completing a senior thesis in philosophy. Individual tutorials, substantial written work. Senior standing as philosophy major and consent of faculty sponsor required. (ND)

Phil 391. Senior Thesis (4)
Continuation and completion of Phil 390 under the guidance of a faculty sponsor. Prerequisite: Phil 390; consent of faculty sponsor required. (ND)

**Physics**

**Professors.** Arnold H. Kritz, Ph.D. (Yale), chair; Garold J. Borse, Ph.D. (Virginia), associate chair; Gary G. DeLeo, Ph.D. (Connecticut), associate dean of arts & sciences; Robert T. Folk, Ph.D. (Lehigh); W. Beall Fowler, Ph.D. (Rochester); James D. Gunton, Ph.D. (Stanford); A. Peet Hickman, Ph.D. (Rice); John P. Hueneke, Ph.D. (Colorado); Alvin S. Kantofsky, Ph.D. (Pennsylvania); Yong W. Kim, Ph.D. (Michigan); Sheldon H. Radin, Ph.D. (Yale); Michael Stavola, Ph.D. (Rochester); Jean Toulouse, Ph.D. (Columbia).

**Associate professors.** Daniel C. Hong, Ph.D. (Boston Univ.); Jerome C. Licini, Ph.D. (M.I.T.); Michelle S. Malcuit, Ph.D. (Rochester); H. Daniel Ou-Yang, Ph.D. (U.C.L.A.); Russell A. Shaffer, Ph.D. (Johns Hopkins); Alan D. Streater, Ph.D. (Colorado).

Physics students study the basic laws of mechanics, heat and thermodynamics, electricity and magnetism, optics, relativity, quantum mechanics, and elementary particles. The student also studies applications of the basic theories to the description of bulk matter, including the mechanical, electric, magnetic, and thermal properties of solids, liquids, gases, and plasmas, and to the description of the structure of atoms and nuclei. In addition, the student develops the laboratory skills and techniques of the experimental physicist, skills that can be applied in the experimental search for new knowledge or in applications of the known theories.

A majority of physics graduates go to graduate school in physics, often earning the Ph.D. degree. These people take university or college faculty positions, or work on research in a variety of university, government, or industrial laboratories. Some students choose employment immediately after the bachelor’s degree. They use their many approved and free electives to supplement their science background with applied courses, such as engineering, to develop the skills needed for a position in a particular area.

Because of the fundamental role of physics in all the natural sciences, students also use the physics major as an excellent preparation for graduate study in many other scientific areas, such as applied mathematics, computer science, biophysics, molecular biology, astrophysics, geology and geophysics, materials science and engineering, meteorology, or physical oceanography. Attractive engineering areas with a high science content include aeronautical engineering; nuclear engineering, including both fission and fusion devices; electrical engineering, including instrumentation, electronics, and solid-state devices, electrical discharges and other plasma-related areas; and mechanical engineering and mechanics, including fluids and continuum mechanics. The broad scientific background developed in the physics curriculum is also an excellent background for professional schools, such as law (particularly patent law), medicine, and optometry.

Lehigh offers three undergraduate degrees in physics: the bachelor of arts with a major in physics and the bachelor of science in physics in the College of Arts and Sciences, and the bachelor of engineering physics in the P.C. Rossin College of Engineering and Applied Science. In addition, there are several five-year, dual-degree programs involving physics: The arts-engineering program (see the Arts-Engineering section of this catalog), the combination of the bachelor of science program in the College of Arts and Sciences with Electrical Engineering (described below), and the combination of electrical engineering and engineering physics (see the Electrical Engineering and Engineering Physics section of this catalog).
The bachelor of science curriculum in the College of Arts and Sciences requires somewhat more physics and mathematics than the bachelor of arts major, while the latter provides more free electives and three fewer hours for graduation. By making good use of the electives in these programs, either can prepare a student for graduate work in physics or the physical aspects of other sciences or engineering disciplines, or for technical careers requiring a basic knowledge of physics. The bachelor of arts curriculum is particularly useful for those planning careers in areas where some knowledge of physics is needed or useful, but is not the main subject, such as science writing, secondary school teaching, patent law, or medicine.

The bachelor of engineering physics curriculum in the College of Engineering and Applied Science requires an engineering concentration in either solid state electronics or optical sciences, in addition to regular physics and mathematics courses. This four-year program prepares students to do engineering work in an overlap area between physics and engineering, which may be engineering in a forefront area in which it is desirable to have more physics knowledge than the typical engineer has, or may be experimental physics which either relies heavily on forefront engineering or in which the nature of the problem dictates that scientists and engineers will accomplish more working together rather than separately.

A comparison of the curricula in terms of credit hours in various broad categories is given below.

<table>
<thead>
<tr>
<th>College of Arts and Sciences</th>
<th>College of Engineering and Applied Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.A.</td>
<td>B.S.</td>
</tr>
<tr>
<td>Freshman English</td>
<td>6</td>
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<tr>
<td>Distribution Courses*</td>
<td>20</td>
</tr>
<tr>
<td>Required preliminary and major courses</td>
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<tr>
<td>Approved Electives</td>
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<td>Electives</td>
<td>26</td>
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<td>Total</td>
<td>121</td>
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</table>

*Not including mathematics or science

The recommended sequences of courses are:

<table>
<thead>
<tr>
<th>Freshman Year</th>
<th>Fall Semester</th>
<th>Spring Semester</th>
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</thead>
<tbody>
<tr>
<td>Eng 1</td>
<td>(3)</td>
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<tr>
<td>Phy 11</td>
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<td>(1)</td>
<td>Arts 1</td>
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<tr>
<td>Total</td>
<td>(16)</td>
<td>(15)</td>
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P.C. Rossin College of Engineering & Applied Sciences
Bachelor of Engineering Physics

Senior Year

<table>
<thead>
<tr>
<th>Phy 171</th>
<th>(1)</th>
<th>Phy 340</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elective</td>
<td>(6)</td>
<td>Dist. Req.</td>
</tr>
</tbody>
</table>

*or an equivalent course in scientific computing

For the Bachelor of Arts curriculum:

- At least one of the three advanced physics laboratories (Phy-190, Phy-260, or Phy-261) is required.
- A total of 18 credits of advanced physics courses (200 or 300 level). At least two of these courses must be at the 300 level.
- Approved Electives are subject to the approval of the students advisor, and should be chosen to provide a coherent program to satisfy the student’s goals, such as an interdisciplinary area of science, medical school, law school, teaching certification, science writing, etc.

For the Bachelor of Science curriculum:

- Approved electives include at least 14 credit hours of physics, physical science, or technical courses. Included in this group must be two of the following courses: Phy 363, 369, (352 or 355), and (348 or 365). Students planning graduate work in physics are advised to include Phy 273 and 369 among their electives.

Up to six credit hours of the following courses may be included as part of the credit hours required for graduation: Aerospace Studies, Jour 1-10, Military Science, and Mus 21-78.
The combined arts/engineering programs resulting in bachelors
SSEElec or SSE Elec • (3) first four years. The suggested curricula are:
Combined B.S.(Physics)/B.S.(Electrical Engineering)
The combined arts/engineering programs resulting in bachelors
degrees in both physics and electrical engineering may be
arranged so that either of the two degrees is completed within the
first four years. The suggested curricula are:

<table>
<thead>
<tr>
<th>Fall Semester</th>
<th>Spring Semester</th>
<th>Fall Semester</th>
<th>Spring Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman Year</td>
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<tr>
<td>Engl 1 (3)</td>
<td>Eng 2, 4, 6, 8, 10</td>
<td>Engl 1 (3)</td>
<td>Eng 2, 4, 6, 8, 10</td>
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<td>Phy 11 (4)</td>
<td>Chm 21 (4)</td>
<td>Phy 11 (4)</td>
<td>Chm 21 (4)</td>
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<td>Math 21 (4)</td>
<td>Math 22 (4)</td>
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<td>HSS+ (3)</td>
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<tr>
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<td>Sophomore Year</td>
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<td>Phy 21 (4)</td>
<td>Phy 31 (4)</td>
<td>Phy 21 (4)</td>
<td>Phy 31 (4)</td>
</tr>
<tr>
<td>Phy 22 (4)</td>
<td>Eco 1 (4)</td>
<td>Phy 22 (4)</td>
<td>Eco 1 (4)</td>
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<td>Math 23 (4)</td>
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<td>ECE 108 (4)</td>
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<td></td>
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<td>Junior Year</td>
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<td></td>
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<tr>
<td>Phy 212 (3)</td>
<td>Phy 213 (3)</td>
<td>Phy 212 (3)</td>
<td>Phy 213 (3)</td>
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<tr>
<td>Phy 215 (4)</td>
<td>Phy 264 (3)</td>
<td>ECE 121 (2)</td>
<td>ECE 126 (3)</td>
</tr>
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<td>Phy 260 (2)</td>
<td>Phy 261 (2)</td>
<td>ECE 123 (3)</td>
<td>ECE 138 (2)</td>
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<td>Math 322 (3)</td>
<td>Phy 362 (3)</td>
<td>Math 208 (3)</td>
<td>ECE 136 (3)</td>
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<td>Senior Year</td>
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<tr>
<td>Phy 340 (3)</td>
<td>Phy 171 (1)</td>
<td>ECE 111 (1)</td>
<td>Phy 264 (3)</td>
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<td>Phy Appr</td>
<td>Phy Appr</td>
<td>ECE Appr (3)</td>
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<td>Elective (5)</td>
<td>Elective (9)</td>
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<td>ECE 121 (2)</td>
<td>ECE 126 (3)</td>
<td>ECE 251 (2)</td>
<td>Phy 362 (3)</td>
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<td>ECE 138 (2)</td>
<td>Phy 215 (4)</td>
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<td>ECE 125 (3)</td>
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<tr>
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<td>Elective (3)</td>
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<td>Fifth Year</td>
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<td>ECE 111 (1)</td>
<td>ECE 136 (3)</td>
<td>Phy 340 (3)</td>
<td>Phy 171 (1)</td>
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<td>ECE Appr</td>
<td>ECE Appr</td>
<td>Phy Appr (5)</td>
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<tr>
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<td>Elective (9)</td>
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<tr>
<td>ECE 251 (2)</td>
<td>Electives (3)</td>
<td>Phy 260 (2)</td>
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<tr>
<td>Math 231 (3)</td>
<td>Math 322 (3)</td>
<td>Electives (9)</td>
<td></td>
</tr>
</tbody>
</table>

Physics approved electives: two courses selected from Phy 363, 369, (352 or 355), and (346 or 365).
ECE approved electives must include sufficient numbers of
design credits to satisfy ABET requirements.

Research opportunities. A majority of physics and engineering
physics majors take advantage of opportunities to participate in
research under the direction of a faculty member. Research
areas available to undergraduates are the same as those
available to graduate students; they are described below under
the heading For Graduate Students. Undergraduate student
research is arranged informally as early as the sophomore (or,
occasionally, freshman) year at the initiation of the student or
formally as a senior research project. In addition, a number of
students receive financial support to do research during the
summer between their junior and senior years, either as Physics
Department Summer Research Participants or as Sherman
Fairchild Scholars.

The use of electives. The electives provided in each of the
physics curricula provide the student with an opportunity to
develop special interests and to prepare for graduate work in
various allied areas. In particular, the many available upper-level
physics, mathematics, and engineering courses can be used by
students in consultation with their faculty advisors to structure
programs with special emphasis in a variety of areas such as
solid-state electronics or biophysics.

Departmental Honors. Students may earn departmental
honors by satisfying the following requirements:

- Grade point average of at least 3.50 in physics courses.
- Satisfactorily completing the following courses (these may be
  included in the list of approved electives): Phy 369; two of Phy
  348, 363 and (352 or 355); one 400-level physics course.
- Six credits Phy 273 (Research) plus submission of a written
  report and an oral presentation open to faculty and students.

Five-year combined bachelor/master's programs. Five-year
programs that lead to successive bachelor and master's degrees
are available. These programs satisfy all of the requirements of
one of the three bachelor's degrees in physics (B.S., B.S., B.S.E.P.)
plus the requirements of the M.S. in physics in the final year.
Depending upon the undergraduate degree received, one
summer in residence may be required. Interested students
should contact the associate chair of physics no later than the
spring semester of their junior year for further detail.

The minor program. The minor in physics consists of 15
credits of physics courses, excluding Physics 5. No more than
one physics course required in a student's major program may
be included in the minor program. The minor program must be
designed in consultation with the physics department chair.

Undergraduate Courses in Physics

Phy 5. Concepts in Physics (4)
Fundamental discoveries and concepts of physics and their
relevance to current issues and modern technology. For
students not intending to major in science or engineering.
Lectures, demonstrations, group activities, and laboratories
using modern instrumentation and computers. This is a non-
calculus course; no previous background in physics is assumed.
Three class meetings and one laboratory period per week. No
prerequisites. Fowler. (NS)
Phy 9. Introductory Heat and Thermodynamics (1)
Temperature, heat, and the laws of thermodynamics; kinetic theory of gases. The student will be scheduled for the appropriate part of Phy 11. Prerequisites: three credit hours of advanced placement, anticipatory exam, or transfer credit for the mechanics part of Phy 11, and consent of the chair of the department.

Phy 11. Introductory Physics I (4)
Kinematics, frames of reference, laws of motion in Newtonian theory and in special relativity, conservation laws, as applied to the mechanics of mass points; temperature, heat and the laws of thermodynamics; kinetic theory of gases. Two lectures and two recitations per week. Prerequisite: Math 21, 31 or 51, previously or concurrently. Folk or Licini. (NS)

Phy 12. Introductory Physics Laboratory I (1)
A laboratory course taken concurrently with Phy 11. Experiments in mechanics, heat, and DC electrical circuits. One three-hour laboratory period per week. Prerequisite: Phy 11, preferably concurrently. Malcuit

Phy 13. General Physics (3)
A continuation of Phy 11, primarily for students in the College of Arts and Sciences and premedical students. Electrostatics, electromagnetism, light, atomic physics, nuclear physics and radioactivity. Prerequisites: Phy 11 and Math 21, 31 or 51. Fowler or Shaffer (NS)

Phy 14. General Physics Laboratory (1)
A laboratory course to be taken concurrently with Phy 13. Prerequisite: Phy 12; Phy 13, preferably concurrently. Folk

Phy 19. Introductory Optics and Modern Physics (1)
Physical and geometrical optics; introduction to modern physics. The student will be scheduled for the appropriate part of Phy 21. Prerequisites: three credit hours of advanced placement, anticipatory exam, or transfer credit for the electricity and magnetism part of Phy 21, and consent of the chair of the department. (NS)

Phy 21. Introductory Physics II (4)
A continuation of Phy 11. Electrostatics and magnetostatics; DC circuits; Maxwell's equations; waves; physical and geometrical optics; introduction to modern physics. Two lectures and two recitations per week. Prerequisite: Phy 11; Math 23, 32, or 52, previously or concurrently. Radin or Streater. (NS)

Phy 22. Introductory Physics Laboratory II (1)
A laboratory course to be taken concurrently with Phy 21. One three-hour laboratory period per week. Prerequisite: Phy 12; Phy 21, preferably concurrently. Folk

Phy 31. Introduction to Quantum Mechanics (3)
Experimental basis and historical development of quantum mechanics; the Schroedinger equation; one-dimensional problems; angular momentum and the hydrogen atom; many-electron systems; spectra; selected applications. Three lectures per week. Prerequisite: Phy 13 or 21; Math 205, previously or concurrently. Hickman. (NS)

Phy 91. Measurement and Transducers (1)
Computer-assisted laboratory course, dealing with physical phenomena in mechanics, electricity and magnetism, optics, spectroscopy and thermodynamics. Measurement strategies are developed and transducers devised. Computer simulation, analysis software, digital data acquisition. Prerequisites: Phy 21 and 22 or their equivalent or consent of chair. Kim. (NS)

Phy 171. Physics Proseminar (1)
Discussion of current problems in physics. Intended for seniors majoring in the field. Malcuit. (NS)

Phy 190. Electronics (3)
DC and AC circuits, diodes, transistors, operational amplifiers, oscillators, and digital circuitry. Two laboratories and one recitation per week. Prerequisites: Phy 21 and 22, or Phy 13 and 14. Stavola. (NS)

For Advanced Undergraduates And Graduate Students
Phy 212. Electricity and Magnetism I (3)
Electrostatics, magnetostatics, and electromagnetic induction. Prerequisites: Phy 21 or 13; Math 205, previously or concurrently. Kim. (NS)

Phy 213. Electricity and Magnetism II (3)
Maxwell's equations, Poynting's theorem, potentials, the wave equation, waves in vacuum and in materials, transmission and reflection at boundaries, guided waves, dispersion, electromagnetic field of moving charges, radiation, Lorentz invariance and other symmetries of Maxwell's equations. Prerequisite: Phy 212. Gunton. (NS)

Phy 215. Classical Mechanics I (4)
Kinematics and dynamics of point masses with various force laws; conservation laws; systems of particles; rotating coordinate systems; rigid body motions; topics from Lagrange's and Hamilton's formulations of mechanics; continuum mechanics. Prerequisites: Phy 21 or Phy 13 and Math 205, previously or concurrently. DeLeo. (NS)

Phy 260. Laboratory Techniques (2)
Laboratory practice, including machine shop, vacuum systems, electronic instrumentation, computers and integrated circuits, high-voltage measurements, counting and statistics. Prerequisites: Phy 21 and 22, or Phy 13 and 14. Kanofsky. (NS)

Phy 261. Optics, Spectroscopy, and Quantum Physics Laboratory (2)
Experiments in geometrical optics, interference and diffraction, spectroscopy, lasers, and quantum phenomena. Prerequisites: Phy 21 and 22, or Phy 13 and 14. Malcuit. (NS)

Phy 264. Nuclear and Elementary Particle Physics (3)
Models, properties, and classification of nuclei and elementary particles; nuclear and elementary particle reactions and decays; radiation and particle detectors; accelerators; applications. Prerequisites: Phy 31 and Math 205. Kanofsky. (NS)

Phy 273. Research (2-3)
Participation in current research projects being carried out within the department. Intended for seniors majoring in the field. May be repeated once for credit. (NS)

Phy 281. Basic Physics I (3)
A course designed especially for secondary-school teachers in the master teacher program. Presupposing a background of two semesters of college mathematics through differential and integral calculus and of two semesters of college physics, the principles of physics are presented with emphasis on their fundamental nature rather than on their applications. Open only to secondary-school teachers and those planning to undertake teaching of secondary-school physics. (NS)

Phy 282. Basic Physics II (3)
Continuation of Phy 281. (NS)

Phy 312. Advanced Laboratory (1) fall-spring
Experiments in modern physics designed to introduce students to measuring techniques and phenomena of current interest. Prerequisite: senior or graduate standing in the field, or consent of the department chair. May be repeated for credit. (NS)
Phy 332. (Astr 332) High-Energy Astrophysics (3)
Observation and theory of X-ray and gamma-ray sources, quasars, pulsars, radio galaxies, neutron stars, black holes. Results from ultraviolet, X-ray and gamma ray satellites. Prerequisites: Math 23 or Math 32 or Math 52, previously or concurrently, and Phy 21. McCluskey. (NS)

Phy 340. Thermal Physics (3) fall
Basic principles of thermodynamics, kinetic theory, and statistical mechanics, with emphasis on applications to classical and quantum mechanical physical systems. Prerequisites: Phy 13 or 21, and Math 23, 32 or 52. Gunton. (NS)

Phy 342. (Astr 342) Relativity and Cosmology (3)
Special and general relativity, Schwarzschild and Kerr black holes. Supermassive stars. Relativistic theories of the origin and evolution of the universe. Prerequisites: Math 23 or Math 33 or Math 52, previously or concurrently, and Phy 21. McCluskey. (NS)

Phy 348. Plasma Physics (3)
Single particle behavior in electric and magnetic fields, plasmas as fluids, waves in plasmas, transport properties, kinetic theory of plasmas, controlled thermonuclear fusion devices. Prerequisites: Phy 21, Math 205, and senior standing or consent of the chair of the department. Kritz. (NS)

Phy 352. Modern Optics (3)
Paraxial optics, wave and vectorial theory of light, coherence and interference, diffraction, crystal optics, and lasers. Prerequisites: Math 205, and Phy 212 or ECE 202. Radin. (NS)

Phy 355. Lasers and Non-linear Optics (3)
Basic principles and selected applications of lasers and non-linear optics. Topics include electromagnetic theory of optical beams, optical resonators, laser oscillation, non-linear interaction of radiation with atomic systems, electro- and acousto-optics, optical noise, optical waveguides, and laser devices. Prerequisites: Phy 31; Phy 213 or ECE 203, previously or concurrently. Radin. (NS)

Phy 362. Atomic and Molecular Structure (3)
Review of quantum mechanical treatment of one-electron atoms, electron spin and fine structure, multi-electron atoms, Pauli principle, Zeeman and Stark effects, hyperfine structure, structure and spectra of simple molecules. Prerequisite: Phy 31 or Chm 341. Ou-Yang. (NS)

Phy 363. Physics of Solids (3)
Introduction to the theory of solids with particular reference to the physics of metals and semiconductors. Prerequisite: Phy 31 or Mat 316 or Chm 341, and Phy 340 or equivalent, previously or concurrently. Stavola. (NS)

Phy 365. Physics of Fluids (3)
Concepts of fluid dynamics: continuum and molecular approaches; waves, shocks and nozzle flows; nature of turbulence; experimental methods of study. Prerequisites: Phy 212 or ECE 202, and Phy 340 or ME 104 or equivalent, previously or concurrently. Kim. (NS)

Phy 369. Quantum Mechanics I (3)
Principles of quantum mechanics: Schroedinger, Heisenberg, and Dirac formulations. Applications to simple problems. Prerequisites: Phy 31, Math 205; Phy 215, previously or concurrently. Hickman. (NS)

Phy 372. Special Topics in Physics (1-3)
Special topics in physics not sufficiently covered in the general courses. Lecture and recitations or conferences. (NS)

Phy 382. Applied Solid-State Physics (3)
Introduction to solid-state phenomena and their applications, including the electronic, optical, dielectric, and magnetic properties of solid-state materials. Prerequisite: Phy 363, or consent of the chair of the department. Stavola. (NS)

For Graduate Students
The department of physics has concentrated its research activities within several fields of physics, with the result that a number of projects are available in each area. Current departmental research activities include the following:


Solid-state physics (theoretical). Electronic properties of defects in semiconductors and insulators, electronic structures, electron-lattice interactions, energy band calculations.


Plasma Physics (Theoretical). Studies of heating, current drive, and plasma diagnostics by transient synchrotron radiation in magnetically confined toroidal plasmas. The research is closely related to ongoing and proposed experiments at major fusion laboratories.


Nuclear theory. The few nucleon problem, nuclear structure theory.


Statistical Physics (theoretical). Kinetic theory, statistical basis of hydrodynamics, non-linear processes, bound states and internal degrees of freedom in kinetic theory. Study of pattern formation in dendritic growth.

Elementary particles (experimental). Fermilab and Brookhaven are used in channeling, device development, and particle jet studies.


Non-linear optics. Theoretical and experimental work in lasers and non-linear optics.

Candidates for advanced degrees normally will have completed, before beginning their graduate studies, the requirements for a bachelor's degree with a major in physics, including advanced mathematics beyond differential and integral calculus. Students lacking the equivalent of this preparation will make up deficiencies in addition to taking the specified work for the degree sought.

At least eight semester hours of general college physics using calculus are required for admission to all 200- and 300-level courses. Additional prerequisites for individual courses are noted in the course descriptions. Admission to 400-level courses generally is predicated on satisfactory completion of corresponding courses in the 200- and 300-level groups or their equivalent.

Facilities for Research. A renovation and addition to the Lewis Laboratory has made available many new research
laboratories and improved the quality of the older research space. It also expanded the shop area and provided a direct connection to the Sherman Fairchild Laboratory, where solid-state physics faculty and research space are located.

Among the research equipment available in the various experimental physics laboratories are: three electron spin resonance laboratories; a laboratory for optical detection of magnetic resonance; facilities for optical absorption and luminescence studies; ultraviolet, visible, and infrared spectrophotometers; liquid nitrogen, hydrogen, and helium cryogenic equipment; several shock tubes; film scanning apparatus; cosmic ray detectors; 9-high power lasers (4 argon-ion lasers, 2 tunable pulse dye lasers, a ruby laser, and 2 mode-locked, Q-switched Nd-glass lasers); crystal-growing facilities; a mass-spectrometer, large interferometers, an electron microscope, a high-density plasma source; electronic instrumentation for data acquisition and analysis, including several minicomputers, many microcomputers, and signal averagers.

A 3 MeV Van de Graaff accelerator housed in the Sherman Fairchild Laboratory is used to study radiation defects in solids, to analyze impurity distributions in thin films, to develop instrumentation, and to study channeling and nuclear physics. Also available in materials and electrical engineering laboratories in the Fairchild Laboratory are excellent facilities for the preparation of solid-state materials and the fabrication of solid-state devices; these facilities are heavily used by physics students doing experimental solid-state research.

Graduate Courses in Physics

Phy 411. Survey of Nuclear and Elementary Particle Physics (3)
Intended for non-specialists. Fundamentals and modern advanced topics in nuclear and elementary particle physics. Topics include: nuclear force, structure of nuclei, nuclear models and reactions, scattering, elementary particle classification, SU(3), quarks, gluons, quark flavor and color, leptons, gauge theories, GUT, the big bang. Prerequisite: Phy 369. Shaffer

Phy 420. Mechanics (3)
Includes the variational methods of classical mechanics, methods of Hamilton and Lagrange, canonical transformations, Hamilton-Jacobi Theory. Toulouse.

Phy 421. Electricity & Magnetism I (3)
Electrostatics, magnetostatics, Maxwell’s equations, dynamics of charged particles, multipole fields. Huennekens

Phy 422. Electricity & Magnetism II (3)

Phy 424. Quantum Mechanics II (3)
General principles of quantum theory; approximation methods; spectra; symmetry laws; theory of scattering. Prerequisite: Phy 369 or equivalent. Borse

Phy 425. Quantum Mechanics III (3)
A continuation of Phy 424. Relativistic quantum theory of the electron; theory of radiation. Shaffer

Phy 428. Methods of Mathematical Physics I (3)
Analytical and numerical methods of solving the ordinary and partial differential equations that occur in physics and engineering. Includes treatments of complex variables, special functions, product solutions and integral transforms. Borse.

Phy 429. Methods of Mathematical Physics II (3)
Continuation of Physics 428 to include the use of integral equations. Green’s functions, group theory, and more on numerical methods. Prerequisite: Phy 428. Borse.

Phy 431. Theory of Solids (3)

Phy 442. Statistical Mechanics (3)
General principles of statistical mechanics with application to thermodynamics and the equilibrium properties of matter. Prerequisites: Phy 340 and 369. Toulouse.

Phy 443. Nonequilibrium Statistical Mechanics (3)
A continuation of Phy 442. Applications of kinetic theory and statistical mechanics to nonequilibrium processes; non-equilibrium thermodynamics. Prerequisite: Phy 442. Hong

Phy 444. Atomic and Molecular Physics (3)
Advanced topics in the experimental and theoretical study of atomic and molecular structure. Topics include fine and hyperfine structure, Zeeman effect, interaction of light with matter, multi-electron atoms, molecular spectroscopy, spectral line broadening atom-atom and electron-atom collisions and modern experimental techniques. Prerequisite: Phy 424 or consent of the department. Huennekens

Phy 445. Physics of Nonlinear Phenomena (3)
Basic concepts, theoretical methods of analysis and experimental development in nonlinear phenomena and chaos. Topics include nonlinear dynamics, including period-multiplying routes to chaos and strange attractors, fractal geometry and devil’s staircase. Examples of dissipative and conservative systems will be drawn from fluid flows, plasmas, nonlinear optics, mechanics and waves in disordered media. Prerequisite: graduate standing in science or engineering, or consent of the chair of the department. Kim

Phy 462. Theories of Elementary Particle Interactions (3)
Relativistic quantum theory with applications to the strong, electromagnetic and weak interactions of elementary particles. Prerequisite: Phy 425. Shaffer

Phy 465. Nuclear and Elementary Particle Physics (3)
Nuclear structure and phenomena; interactions among elementary particles and methods of studying them. Kanofsky

Phy 467. Nuclear Theory (3)
Theory of low-energy nuclear phenomena within the framework of nonrelativistic quantum mechanics. Borse

Phy 471. (Mech 411) Continuum Mechanics (3)
An introduction to the continuum theories of the mechanics of solids and fluids. This includes a discussion of the mechanical and thermodynamical bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of theories to specific problems are given.

Phy 472. Special Topics in Physics (1-3)
Selected topics not sufficiently covered in the more general courses. May be repeated for credit.

Phy 474. Seminar in Modern Physics (3)
Discussion of important advances in experimental physics. May be repeated for credit when a different topic is offered.

Phy 475. Seminar in Modern Physics (3)
Discussion of important advances in theoretical physics. May be repeated for credit when a different topic is offered.

Phy 491. Research (3)
Research problems in experimental or theoretical physics.
The major in political science is designed to promote understanding of political ideas, institutions and processes, and to develop skills in analyzing and evaluating political problems.

A balanced program within the discipline, one that exposes the student to various areas of inquiry in political institutions and processes as well as in the comparative and philosophical perspectives of political analysis, has been the way in which the goals of the major program generally have been achieved. While the major program outlined below will prove adequate for most student needs, it may be that because of some special factors such as late transfer or unusual interests and/or abilities the outlined program does not accommodate some students. In that case the students may, in consultation with their advisers, develop a major program that in their judgment will more adequately fulfill those needs.

The faculty adviser to the student majoring in political science is designated by the department. The adviser consults with the student and approves the major program. The adviser attempts to help the student relate courses offered by the department to the student's educational goals. The adviser also may act as a resource for the student, and may suggest courses in other disciplines, language courses, and courses in research techniques that may be of benefit.

A variety of experiential opportunities are available to undergraduates majoring in political science. The department, for example, offers a Community Politics Internship every semester that includes opportunities for internship placements in either local government, private agencies, or law offices. Students are also encouraged to apply for off-campus internship opportunities, e.g., American University's Washington Semester Program and The Philadelphia Center's Internship in Philadelphia.

Completion of the political science major is considered suitable training for the undergraduate who wishes to go on to law school, to become a social science teacher, or to work as a governmental official, party or civic leader, public affairs commentator, or staff member of a government research bureau. In addition, the business sector continues to provide opportunities in areas such as banking, insurance, and marketing for bachelor of arts graduates with training in the social sciences. Graduate study is advisable for students contemplating certain careers: college teaching, research, or public management, for example.

The three core courses are required. Individual exceptions may be made, for good reasons, by the major adviser with the approval of the department chair. Math. 12, Basic Statistics, is highly recommended for students contemplating a major in this department.

**Major Requirements**

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<tr>
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<td>PolS 101</td>
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<td>PolS 102</td>
<td>Modern Political Heritage (4)</td>
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<td>PolS 103</td>
<td>American Political System (4)</td>
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<td>PolS 174</td>
<td>Political Parties and Elections (4)</td>
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<td>Propaganda, Media, and American Politics (4)</td>
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<td>PolS 230</td>
<td>Movements and Legacies of the 1960s (4)</td>
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<td>PolS 233</td>
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<td>PolS 271</td>
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<td>PolS 353</td>
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<td>PolS 375</td>
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<td>PolS 376</td>
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**Political theory and comparative politics**

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<td>PolS 101</td>
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<td>PolS 104</td>
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<td>PolS 130</td>
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<td>PolS 132</td>
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<td>PolS 201</td>
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<td>PolS 237</td>
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<td>PolS 261</td>
<td>Soviet and Post-Soviet Politics (4)</td>
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<td>PolS 264</td>
<td>Issues in Contemporary Political Philosophy (4)</td>
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<td>PolS 362</td>
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<td>PolS 369</td>
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<td>PolS 370</td>
<td>Seminar: The Citizen versus the Administrative State (4)</td>
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<td>PolS 374</td>
<td>Seminar: Third World Issues (4)</td>
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**American politics, public law and interdisciplinary**

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<td>PolS 115</td>
<td>Technology as Politics (4)</td>
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**Public Administration Minor**

The minor consists of two of the three core courses listed above (PolS 1, PolS 3, and PolS 100 or 101 or 102) plus any two other political science courses for a total of 16 credits.

**Political Science Minor**

The minor consists of PolS 260 plus three other courses chosen in consultation with the adviser for a minimum of 15 credits.
Political Science Honors
Students must have at least a 3.2 cumulative grade point average, and a 3.3 major grade point average, in order to proceed with departmental honors. Students with honors must complete ten courses in the major, including an independent study focusing on the honors thesis.

Undergraduate Courses
PolS 1. American Political System (4) fall-spring
Constitutional principles; organization and operation of the national government; and dynamics of power within the U.S. political system. (SS)

PolS 3. Comparative Politics (4) fall-spring
The political systems of foreign countries; approaches to the study of comparative politics. (SS)

PolS 100. Introduction to Political Thought (4)
Some of the most significant ancient and modern political theorists: Plato, Aristotle, Machiavelli, Hobbes, Marx, and others. Matthews (ND)

PolS 101. Ancient Political Heritage (4)
Important political thinkers from the pre-Socratics to early, modern political theorists like Machiavelli. Matthews (SS)

PolS 102. (Phil 102) Modern Political Heritage (4)
Begins where PolS 101 ends: from early, modern theorists (e.g., Hobbes) up to contemporary thinkers (e.g., Marcuse). Matthews (SS)

PolS 111. The Politics of the Environment (4)
A survey of the major environmental, resource, energy and population problems of modern society, focusing on the United States. The politics of man’s relationship with nature, the political problems of ecological scarcity and public goods, and the response of the American political system to environmental issues. Wurth (SS)

PolS 115. Technology as Politics (4)
Relationship of technology and technological change with politics and public policy. Review of theories of political significance of technology, including technological determinism, technology assessment, technological progress and appropriate technology. Specific issues in technology with emphasis on U.S. economy. (ND)

PolS 125. (IR 125) International Political Economy (4)
Principles governing the interaction between the economic and political components of international phenomena. Political causes and consequences of trade and investment. Foreign economic policy in its relationship to domestic economic policy and other aspects of foreign policy. Determinants of foreign economic policy. Prerequisites: Economics 1 or 11 or 12; IR 10. Moon, Barkey (SS)

PolS 132. (Hist, IR) An Introduction to Canada (4)
An interdisciplinary, team-taught course focusing on history, politics, economics and international relations. Topics covered will include Canada’s historical development, recent politics and foreign policy, and economic and trade issues. Special attention will be given to contemporary affairs and to Canada’s relations with the United States. (SS)

PolS 174. Political Parties and Elections (4)
Organization, functions, and behavior of parties in the United States; voting behavior, campaigns, and elections. Colon (SS)

PolS 177. Urban Politics (4)
The structure and processes of city government in the United States; city-state and federal-city relationships; the problems of metropolitan areas; political machines and community power structures; the urban politics of municipal reform; city planning and urban renewal. Colon (SS)

PolS 179. (WS 179) Politics of Women (4)
Selected social and political issues relating to the role of women in American society. Focuses on such questions as economic equality, poverty, and work roles, the older woman, gender gap, political leadership, reproduction technology, and sexual violence. Olson (SS)

For Advanced Undergraduates and Graduate Students
PolS 201. Current Political Controversies (4)
Selected topical policy issues and alternative approaches to understanding them. Including issues such as problems facing the current president, controversies in Eastern Europe, reproductive technologies, and crises in the American political economy. (SS)

PolS 202. Comparative State Politics (4)
Analysis of major questions relating to the role of the states in the American federal system and their relationship with the national government. Colon (SS)

PolS 206. Public Policy Process (4)
Power relations and their impacts on selected public policy issues, specifically taxation, housing, environment, poverty, energy, the military, and health. Olson (SS)

PolS 213. Teaching Government (4)
Contemporary issues in the teaching of social studies in public and private schools, including those government decisions that affect the educational environment. The course focuses attention on a specific issue such as urban problems, comparative political systems, ideologies and American political institutions and processes. Designed primarily for secondary school teachers. (SS)

PolS 214. Workshop in Teaching Government (4)
Individual research projects, contemporary issues and discussion of proposals for curriculum revisions in the public and private schools. Outside speakers will be invited to attend workshop sessions. Must be taken concurrently with PolS 213 when courses are offered together. (ND)

PolS 217. The American Presidency (4)
Role of the executive in the American political process. Includes an analysis of the historical development, selection process, and scope of executive power. Emphasizes domestic and foreign policy initiatives of selected presidents from FDR to today. Prerequisite: PolS 1. Olson (SS)

PolS 218. Seminar in Post-Soviet Politics (4)
Analysis of selected issues in the politics of the former USSR. Prerequisites: PolS 261 or consent of the instructor. Barry (SS)

PolS 221. Research in Political Science (4)
Models in the explanation of political phenomena, appropriateness of measurement techniques; construction of research designs; rationale and application of statistical analyses; individual projects involving the construction and testing of models employing a major social science data set. Prerequisite: Consent of the instructor. Davis (ND)

PolS 222. Politics of Developing Nations (4)
Theories of non-Western economic and political development. Human costs for both men and women of development models and their failures. Student groups evaluate models using case-studies primarily from Latin America and Africa. Team approach to analyzing and solving complex development problems in contemporary contexts. Prerequisite: PolS 3. Stewart-Gambino (SS)
PolS 227. Socialization and the Political System (4)
The social, ideological, and economic foundations of American politics. Emphasis on supporting institutions—family, schools, and workplace—plus processes that foster political attitudes and behavioral patterns. Morgan (SS)

PolS 229. Propaganda, Media, and American Politics (4)
Seminar on the role of propaganda with emphasis on mass culture, television, and the relationship between government and mass media. U.S. foreign and domestic policy analyzed using critical propaganda theories. Prerequisite: junior standing. Morgan (ND)

PolS 230. Movements and Legacies of the 1960's (4)
The lessons and legacies of 1960's social and political movements, including civil rights, black power, the New Left, campus protests, the Vietnam war and antirwar movement, the counterculture, women's and ecology movements. Prerequisite: junior standing. Morgan (SS)

PolS 231. Community Politics Internship (4)
Integrated fieldwork and academic study. Seminar, research paper, and journal; internship with government and social service agencies, political groups, elected officials, and law offices. May be repeated for credit. Prerequisite: consent of instructor. (ND)

PolS 233. (Psych 333, SSP 333) Social Psychology of Politics (4)
Political behavior viewed from a psychological and social psychological perspective. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Rosenwein (SS)

PolS 235. Latin American Political Systems (4)
Democratic, authoritarian and revolutionary paths to contemporary political issues. Political, economic and social implications of contemporary "democratic" regimes and non-liberal economic policies. Discussion groups and student presentations on prospects for democratic peace and prosperity in the future. Prerequisite: PolS 3. Stewart-Gambino (ND)

PolS 236. U.S. Foreign Policy and Latin America (4)
U.S. historical relationship with Central America, Caribbean and South America with emphasis on economic and military dominance. Contemporary issues such as U.S. invasions of Panama and Grenada, U.S. Cuban relations, the militarization of the "drug" war, counterinsurgency. Written analysis of competing U.S. interests across time and regions. Prerequisite: PolS 3. Stewart-Gambino (ND)

PolS 237. Religion and Politics in Latin America (4)
Indigenous and "imported" religious structures, the prominent role of the Catholic Church in Latin America, and the recent explosion of Protestant/Pentecostal churches. Emphasis on the intersection of religious belief and power (i.e., gender, local politics, national development, etc.). Short papers integrate material with students' knowledge of religious/political phenomena. Discussion groups analyze philosophical foundations of belief. Prerequisite: PolS 3 and 236. Stewart-Gambino (ND)

PolS 239. (WS 239) Women and Development (4)
Focus on gender implications of contemporary strategies for economic growth, neo-liberal development models, and mainstream methodologies for field research in Third-World countries. Emphasis on multiple writing assignments, group and individual projects on specific regions and countries, and rigorous research/critical skills. Prerequisite: PolS 3. Stewart-Gambino (SS)

PolS 250. Constitutional Law (4)
The law of the Constitution as expounded by the Supreme Court of the United States. Nature and origins of judicial review, distribution and scope of governmental powers, and economic regulation in a federal system. Detailed consideration of judicial policy decision-making processes. Kersch (ND)

PolS 252. Civil Rights (4)
A study of constitutional development in political and civil rights. Freedom of speech and of the press, religious freedom, due process of law and equal protection of the laws. Detailed consideration of constitutional issues concerning criminal procedure and racial discrimination. Kersch (ND)

PolS 254. Politics of the Administrative Process (4)
The authority, procedures, and methods used by executive agencies in the administration of public policy. Analysis of the general problem of adjusting the administrative process to traditional constitutional principles. Barry (ND)

PolS 259. U.S. Congress (4)
Elections for the House and Senate and their significance for the way in which Congress functions. The formal structure of party leadership and committees, House and Senate organizational and functional differences, and informal and formal power of legislation and oversight. Congressional relations with the president, bureaucracy, and Supreme Court. Prerequisite: PolS 1. Davis (SS)

PolS 260. Public Administration (4)
The nature of administration; problems of organization and management; public personnel policies; budgeting and budgetary system; forms of administrative responsibility. Colon (ND)

PolS 261. Soviet and Post-Soviet Politics (4)
The political systems of the former USSR. The evolution of the Soviet system; the Gorbachev era; the search for new political arrangements. While all of the former Soviet republics will be open for examination in this course, emphasis in the post-Gorbachev period will be placed on the Russian Federation. Barry (ND)

PolS 264. (Phil 264) Issues in Contemporary Political Philosophy (4)
Selected topics in contemporary political philosophy, such as the Frankfurt school, existentialism, legitimation, authenticity, participatory democracy, and the alleged decline of political philosophy. May be repeated for credit with the consent of instructor. Matthews (SS)

PolS 265. (Phil 265) American Political Thought (4)
A critical examination of American political thought from the founding of the Republic to the present. Writings from Madison, Hamilton, and Jefferson to Emma Goldman, Mary Daly, Malcolm X, Henry Kariel, and others will be discussed. Matthews (SS)

PolS 268. Political Economy (4)
Relationship of democratic politics to government and market, and significance of economic power in the American polity. Economic rationale for the place of the market and economic institutions in polity. Comparison of economic approaches to public policy and organization, like public goods, market failure and collective action with traditional political science approaches. Group mobilization and conflict, non-decisions, and symbolic action. Wurth (ND)

PolS 271. U.S. Politics and the Environment (4)
An examination of contemporary American politics and policy dealing with environmental issues. Current controversies in the legislative and regulatory areas will be covered to examine environmental issues and the political process. Significant portions of the course readings will be taken from government publications. Wurth (SS)
PolS 353. Seminar: Media, Propaganda and Democracy (4)
Research seminar on theoretical and applied issues related to
democracy vs. political hegemony, as affected by propaganda,
the mass media, popular culture, and the capitalist economy.
Students will pursue individual research topics linked to
common class readings. Weekly paper presentations and critical
responses. Prerequisite: Either PolS 229 or both Jour 246 and SSP
337. Morgan (SS)

PolS 356. Seminar: Political Philosophy (4)
Critical examination of several of the "great books" and/or
"great ideas" in political thought. Students will be required to
write a major paper and present their thought to the class.
Matthews (SS)

PolS 358. Seminar: Interest Groups, Fractions, and Coalitions in
American Politics (4)
The rise of interest group power. Social, economic, and political
reasons for groups' increasing influence. Value of different
group resources and influence in particular national policy
arenas. Types of more, and less, powerful interests, and the
implications of this distribution of power for American politics.
Davis (SS)

PolS 362. Seminar: American Political Thought (4)
Focus on a narrow topic or theorist in the field—e.g., the work
of Jefferson, Madison, Hamilton, or Tocqueville. Students will be
required to write a major paper and present it to the class.
Matthews (SS)

PolS 366. Seminar: American Politics (4)
Study of the organization, functions, and behavior of political
political parties in the United States. Includes voting behavior,
campaigns and elections, polling, interest groups, public opinion
and the role of the media. Colon (SS)

PolS 369. Seminar: Transitions to Democracy (4)
The theoretical and comparative literature on transitions from
authoritarianism toward democracy, with particular attention to
the former Soviet Union. Barry (SS)

PolS 370. Seminar: The Citizen versus the Administrative State (4)
Administrative power and policy. Constitutional and judicial
control of administration. Remedies against improper
administrative acts. Major emphasis will be on the United States,
with some attention given to analogous issues in other countries.
Barry (SS)

PolS 371. Readings (1-4)
Readings in political science assigned to properly qualified students
in consideration of their special interest in particular political
institutions and practices. Prerequisite: consent of instructor. (ND)

PolS 372. Readings (1-4)
Continuation of PolS 371. Prerequisite: consent of instructor. (ND)

PolS 373. Seminar: Public Administration (4)
Public and nonprofit administrative agencies. Focus on the
national government administration, but state, municipal, and
nonprofit agencies included. Problems of organization and
management; personnel policies; budgeting and financial
systems; and forms of administrative responsibility. Colon (SS)

PolS 374. Seminar: Third World Issues (4)
Focus on Nancy Sheper-Hughes' Death Without Weeping: The
Violence of Everyday Life in Brazil with discussion of "objectivity"
in field research, separation between advocacy and observation,
and gendered subjects. Student presentations of research topics
in latter part of course, emphasizing professional form and
collegial cooperation. Prerequisites: PolS 222, 235, 236, 237, or
consent of instructor. Stewart-Gambino (SS)

PolS 375. Seminar: Green Polity (4)
Development of guidelines and applications for public policy and
political action directed toward environmental sustainability and
political feasibility. Focus on problem-solving and political design,
connecting sustainable environmental goals with workable and
responsive institutional designs. Prerequisites: PolS 111, 368, or
consent of instructor. Wurth (SS)

PolS 376. Seminar: National Social Policy (4)
A readings/research seminar on current social policy questions.
Course analyzes, from alternatives political perspectives, such
issues as Social Security, Medicare, health care, welfare reform,
income inequality, and taxation. Students research a specific
social issue of their choice. Class discussion on individual
research and common readings. Olson (SS)

PolS 381, 382. Special Topics (1-4)
A seminar on a topic of special interest in a particular political
institution, process, or policy. Prerequisite: consent of the
department chair. (ND)

For Graduate Students the department of political science offers
a graduate program leading to the master of arts degree. The
applicant for admission is required to demonstrate adequate
undergraduate preparation. Those seeking full time graduate
studies must submit Graduate Record Examination results.

Master of Arts
The master of arts in political science is a 30-credit-hour
program that can be accomplished in 12 months by full-time
students. A comprehensive examination or thesis is required.
The student may take 24 hours of course work and six hours of
thesis or may take all 30 credit hours in course work. A
graduate-level course in research methods, the American Politics
Core, and Comparative Politics Core are required of all
candidates for the master of arts degree.

The master of arts program is intended for the student with
liberal arts or natural science preparation who has a professional
interest in government. The master of arts may be a preparatory
step toward doctoral work at another institution or research
positions in governmental, institutional or industrial settings or a
final degree preparatory for teaching in junior and community
colleges.

Graduate Courses
PolS 405. The Budgetary Process (3)
The public budgetary process: competition among interest
groups, policy outcomes, intergovernmental relations, and
consequences for policy implementation. Davis

PolS 407. American Constitutional Development (3)
The law of the Constitution as expounded by the Supreme
Court of the United States. Nature and origins of judicial review,
institutional aspects of separation of powers and federalism,
economic regulation in a federal system, and political and civil
rights. Detailed consideration of judicial policy-making processes
and judicial biography.

PolS 408. American Politics Core (3)
A survey of American politics utilizing readings reflecting a
variety of methodological approaches and theoretical
perspectives. Readings include but are not limited to works
widely regarded as "classics" in American political science.

PolS 411. The Legal Foundations of Public Administration (3)
The authority, procedures, and methods used by executive
agencies in the administration of public policy and the general
problem of adjusting the administrative process to traditional
constitutional and legal principles. Barry

PolS 469. Seminar: Transitions to Democracy (3)
The theoretical and comparative literature on transitions from authoritarianism to democracy, with particular attention to the former Soviet Union. Barry

PolS 470. Seminar: The Citizen versus the Administrative State (3)
Administrative power and policy. Constitutional and judicial control of administration. Remedies against improper administrative acts. Major emphasis will be on the United States, with some attention given to analogous issues in other countries. Barry

PolS 471. Seminar in Teaching Government (3)
Theories and techniques of instruction, learning, evaluation, instructional design and innovation in the teaching of government. Prerequisite: permission of the department chair.

PolS 472. Seminar: American Political Thought (3)
Focus on a narrow topic or theorist in the field, e.g., the work of Jefferson, Madison, Hamilton, or Tocqueville. Students will be required to write a major paper and present it to the class. Matthews

PolS 473. Seminar: Public Administration (3)
Public and nonprofit administrative agencies. Focus on the national government administration, but state, municipal, and nonprofit agencies included. Problems of organization and management; personnel policies; budgeting and financial systems; and forms of administrative responsibility. Colon

PolS 474. Seminar: Third World Issues (3)
Focus on Nancy Sheper-Hughes' *Death Without Weeping: The Violence of Everyday Life in Brazil* with discussion of "objectivity" in field research, separation between advocacy and observation, and gendered subjects. Student presentations of research topics in latter part of course, emphasizing professional form and collegial cooperation. Prerequisites: consent of instructor. Stewart-Gambino

PolS 475. Seminar: Green Polity (3)
Development of guidelines and applications for public policy and political action directed toward environmental sustainability and political feasibility. Focus on problem-solving and policy design, connecting sustainable environmental goals with workable and responsive institutional designs. Prerequisites: Both PolS 111 and 368 or consent of instructor. Wurth

PolS 476. Seminar: National Social Policy (3)
A readings/research seminar on current social policy questions. Course analyzes, from alternative political perspectives, such issues as Social Security, Medicare, health care, welfare reform, income inequality, and taxation. Students research a specific social issue of their choice. Class discussion on individual research and common readings. Olson

PolS 478. Seminar: Special Topics (1-3)
Individual inquiry into some problem of government. Reading, field work, and other appropriate techniques of investigation. Conferences and reports. May be repeated for credit.
The bachelor of arts in psychology is a social science major requiring a minimum of 33 credit hours in psychology as defined below. Second-semester freshmen who have completed Psyc 1 can enroll in the 100-level courses by petition and should check with the chairperson of the psychology department if interested.

### Required Major Courses

- Psyc 107: Child Development (3)
- Psyc 108: Seminar in Cognitive Psychology (4)
- Psyc 117: Cognitive Psychology (4)
- Psyc 118: Mind and Brain (4)
- Psyc 119: Introduction to Behavioral Neuroscience (3)
- Psyc 210: Seminar in Social Psychology (3)
- Psyc 312: Interpersonal Behavior in Small Groups (3)
- Psyc 314: Social Cognition and Social Action (4)
- Psyc 315: History of Modern Psychology (4)
- Psyc 318: Seminar in Gender and Psychology (4)
- Psyc 320: Psychology of Language (4)
- Psyc 321: Language Development (4)
- Psyc 323: The Child in Family and Society (3)
- Psyc 327: Health Psychology (4)
- Psyc 331: Humanistic Psychology (4)
- Psyc 332: Social Psychology of Politics (3)
- Psyc 335: Animal Behavior (3)
- Psyc 338: Emotional and Behavioral Disorders of Children (3)
- Psyc 351: Cognitive Development in Childhood (4)
- Psyc 354: Personality Assessment (4)
- Psyc 356: Seminar in Personality Psychology (4)
- Psyc 358: Seminar in Infant Development (4)

### Recommended Electives

The bachelor of arts program in psychology is a flexible preparation for a number of fields. With suitable selection of additional courses, students can prepare themselves for graduate study in any subfield of psychology or for careers in areas for which psychology is a desirable and relevant major such as law, social work, marketing, and education.

For graduate programs in developmental, social/personality, cognitive, and clinical psychology, the following are desirable background:

- Psyc 161: Supervised Research
- Psyc 391, 392: Thesis
- Psyc 393: Independent Research
- Psyc 421, 422: Analysis and Design of Experiments (by petition)

Depending on the specific subfield of interest, any of the following may be useful, as well as other courses not listed here especially including those within the Department of Sociology/Anthropology, the College of Education, and the interdisciplinary programs of cognitive science, women's studies, Africana studies, and behavioral neuroscience.

### Additional Courses

- Math 12: Basic Statistics
- Psyc 162: Psychological Field Work
- CogS 7: Intro to Cognitive Science
- CogS 140: Intro to Linguistics
- CSc 11: Intro to Computing
- CSc 327: Artificial Intelligence Theory and Practice
- Phil 250: Minds of Robots and Other People
- Phil 128: Philosophy of Science
- SSP 135: Human Communication
- SSP 103: Sociological Perspectives on Racial and Ethnic Communities
- Anth 11: Sociocultural Anthropology
- Anth 123: The Cultural Construction of Gender
- Anth 376: Culture and the Individual
- BioS 31: Intro to Cell and Molecular Biology
- BioS 101: Genetics
- EES 31: Intro to Environmental and Organismal Biology

Preparation for programs in health-related areas such as nursing, medicine, and dentistry will include additional coursework in biology, chemistry, and physics. Students should consult with the appropriate pre-professional advisors to determine specific requirements.

Students interested in applying psychology to fields such as law, marketing, social work, or education should consult with faculty in those areas to discuss relevant courses in addition to those listed above.

### Honors Program in Psychology

The honors program permits majors of unusual academic ability and interest to explore topics in greater depth than the curricula normally allow. Under faculty supervision, a student normally
spends the first semester of the senior year doing library research, learning the appropriate methodology, and preparing a written proposal and oral presentation. In the second semester the proposal is implemented, culminating in a written honors thesis and oral presentation. Successful completion of this program results in "Departmental Honors" being affixed to the student's transcript.

Eligibility requirements: Eligible students must be psychology majors; have completed the first semester of the junior year with an overall GPA of 3.0; and have completed a minimum of four psychology courses with a GPA of 3.3. Interested students should contact the chairperson.

The Psychology Minor
The psychology minor consists of a minimum of 15 credit hours in psychology beyond the introductory course (Psyc 1). At least one of these courses must be at the 300-level. The student should consult the department chairperson no later than the fifth semester regarding course selection.

Undergraduate Courses
Psyc 1. Introduction to Psychology (3)
Psychology as a science of behavior. Natural science aspects such as learning, sensation-perception, and physiological bases; and social science aspects such as human development, intelligence, and personality. Methodologies appropriate to these areas, and related societal problems. (SS)

Psyc 2. Introduction to Psychology Directed Study (1)
Discussions and demonstrations related to the topics covered in Psyc 1; supplemental readings and written reports. Strongly recommended for students who plan to major in psychology. Prerequisites: Concurrently enrolled in Psyc 1 and consent of the department chair. Limited enrollment with preference given to freshmen and sophomores in the College of Arts and Sciences. (SS)

Psyc 21. (SSP 21) Social Psychology (3)
Theories, methods of investigation, and results of research in social psychology with emphasis on psychological processes in social behavior, social attitudes, group behavior, and social interaction. (SS)

Psyc 106. Child Development Directed Study (1)
Discussions and projects related to the topics covered in Psyc 107; supplemental readings and written reports. Strongly recommended for students who plan to major in psychology. Prerequisites: Concurrently enrolled in Psyc 107 and consent of the department chair. Limited enrollment with preference given to freshmen and sophomores in the College of Arts and Sciences. (SS)

Psyc 107. Child Development (3)
Survey of theories and research concerning perceptual, cognitive, social, and personality development through infancy and childhood. Prerequisite: Psyc 1 or Psyc/SSP 21. Barrett, McRoberts, Nicolopoulos. (SS)

Psyc 108. Adulthood and Aging Directed Study (1)
Discussions and projects related to the topics covered in Psyc/SSP 109; supplemental readings and written reports. Strongly recommended for students who plan to major in psychology. Prerequisites: Concurrently enrolled in Psyc/SSP 109 and consent of the department chair. Limited enrollment with preference given to freshmen and sophomores in the College of Arts and Sciences. (SS)

Psyc 109. (SSP 109) Adulthood and Aging (3)
Social science approaches to the latter two-thirds of life. Cognitive and personality development; attitudes toward aging; social behavior of older adults; widowhood; retirement. Prerequisite: Psyc 1 or Psyc/SSP 21. Hyland. (SS)

Psyc 110. (BioS 110) Design and Analysis of Experiments (4)
Principles of experimental design and statistical analysis: characteristics of data and data collection; descriptive statistics; hypothesis testing theory and practice; correlation, chi-square, t-test, analysis of variance. Three hours lecture and one hour computer lab. Richter. (ND)

Psyc 117. Cognitive Psychology (4)
The architecture and dynamics of the human mind: How we acquire knowledge through perception, represent and activate it in memory, and use it to communicate, make decisions, solve problems, and reason creatively. Prerequisite: Psyc 1 or CogS 7. Mai, O'Seaghdha. (SS)

Psyc 125. (SSP 125) Social Psychology of Small Groups (3)
Theories and empirical research regarding interpersonal behavior in small groups. Classroom exercises and group simulations. Prerequisite: consent of instructor. Rosenwein. (SS)

Psyc 135. (SSP 135, Jour 135) Human Communication (3)
Processes and functions of human communication in relationships and groups. Rosenwein. (SS)

Psyc 140. (Anh 140, CogS 140, MLL 140) Introduction to Linguistics (3)
Relationship between language and mind; formal properties of language; language and society; how languages change over time. (SS)

Psyc 142. (AAS 142) The Psychology of African Americans (4)
Presentation of a range of writings on the psychology of African Americans; exploration of significant perspectives in understanding the psychological dynamics, popular culture, current research, and cultural implications of Black Americans entering the 21st century. Lectures and discussion. Prerequisite: By the consent of the instructor. (SS)

Psyc 153. (SSP 153) Personality (4)
Review and critique of theories of personality and their associated systems of psychotherapy. Prerequisite: Psyc 1, Psyc 21 or SSP 21. Gill, Newman, Williams. (SS)

Psyc 154. Introduction to Clinical Psychology (3)
Survey of clinical psychology as a science and profession. Current psychological treatment approaches, assessment techniques, research strategies, and their empirical and theoretical foundations. Also discusses the training of clinical psychologists and ethical issues in clinical research and practice. Prerequisite: Psyc 1. Williams. (SS)

Psyc 160. Independent Study (1-3)
Readings on topics selected in consultation with a staff member. Prerequisites: Psyc 1 and consent of the department chair. May be repeated for credit. (SS)

Psyc 161. Supervised Research (1-3)
Apprenticeship in ongoing faculty research program. Literature review, experimental design, data collection and analysis, and professional writing under faculty sponsor supervision. May be repeated once for credit. Prerequisites: Psyc 1 or CogS 7 and consent of sponsor. (SS)

Psyc 162. Psychological Field Work (1-3)
Work-study practice including supervised experience in one of several local agencies. Development of familiarity with the operations of the agency and working with individual patients or students. Prerequisites: Psyc 1 plus two additional psychology courses and consent of instructor. (SS)
Psyc 176. Mind and Brain (4)
Perception and cognitive neuroscience as the link between mental processes and their biological bases. Visual and auditory perception; the control of action; neuropsychological syndromes of perception, language, memory and thought; neural network (connectionist) models of mental processes. Prerequisite: Psyc 1 or Cogs 7. O'Seaghdha, McRoberts. (NS)

Psyc 177. (BioS 177) Introduction to Behavioral Neuroscience (3)
Nervous system functioning with varying emphasis on neurophysiology, neuroanatomy, behavior genetics, information transmission, research techniques, sensory and motor functions. Prerequisite: BioS 31 or EES 31. Nyby, Simon. (NS)

Psyc 210. Experimental Research Methods and Laboratory (4)
Designing, conducting, and reporting psychological experiments. Laboratory exercises, report writing, and a group research project. Prerequisites: Psyc 1 and 110 and consent of department chair. (ND)

Psyc 301. Industrial Psychology (3)
Psychological concepts and methods applied to business and industrial settings. Personnel selection, placement and training, leadership, work motivation, job satisfaction and consumer behavior. Not open to students who took Psyc 201.
Prerequisite: Psyc 1. (SS)

Psyc 305. Abnormal Psychology (4)
Examines theory and research on the patterns, causes, and treatment of various forms of abnormal behavior. Prerequisite: Psyc 153 or consent of the department chair. Williams. (SS)

Psyc 307. Seminar in Cognition (4)
In depth exploration of a selected area of higher cognition, for example, thinking and reasoning; metacognition; theories of memory; expertise; and language and thought. Topic varies by year. Readings, hands-on demonstrations, and a research paper.
Prerequisite: Psyc 117 or 176 or Cogs 7 or consent of instructor. O'Seaghdha, Malt. (SS)

Psyc 308. (SSP 308) Seminar in Social Psychology (3)
Intensive consideration of selected topics in current theory and research in social psychology. The subject matter varies from semester to semester, and includes such topics as the social psychology of education, the applications of perception and learning theory to social psychological problems, the social psychology of science, and the social environment of communication. May be repeated for credit. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission.
Psyc 309. Seminar in Social Psychology (4)

Psyc 312. (SSP 312) Interpersonal Behavior in Small Groups (3)
Intensive consideration of theoretical and methodological issues in the analysis of the development of small groups. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Rosenwein. (SS)

Psyc 314. (SSP 314) Social Cognition and Social Action (4)
Examines the formation of beliefs about social groups, individuals, the self, and the world. Consequences and validity of those beliefs are considered. Areas of inquiry include stereotypes and prejudice, impression formation processes, the self, attitudes and persuasion, and social influence. Prerequisite: Psyc 110 or SR 111. Gill. (SS)

Psyc 315. History of Modern Psychology (4)
Origin and development of major theories within perception, cognition, biological, clinical, personality, developmental, learning. 19th and 20th century thought to provide an overview of psychology as a discipline. Prerequisites: two 300-level Psyc courses. Newman (SS)

Psyc 318. (WS 318) Seminar in Gender and Psychology (4)
Gender as shaped by psychological and social psychological processes. Socialization, communication and power, gender stereotypes, methodological issues in sex differences research.
Prerequisite: Psyc 210 completed or concurrent or permission of instructor. Hyland. (SS)

Psyc 320. Psychology of Language (4)
Psychological processes involved in language comprehension, production, and use. Topics include the relation of language to thought; word meaning; speech perception; language acquisition; sign language. Prerequisite: Psyc 117 or 176 or Cogs 7 or consent of instructor. Malt, O'Seaghdha (SS)

Psyc 321. Language Development (4)
Descriptive and theoretical accounts of the development of language. Primary focus is on the development of spoken language in infancy and early childhood. Involves observation of children at various stages of language development.
Prerequisite: Psyc 107 or 117. McRoberts. (SS)

Psyc 322. (SSP 322) The Child in Family and Society (3)
Influences such as marital discord, family violence, poverty and prejudice on the development of the child from birth through adolescence.
Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Herrenkohl. (SS)

Psyc 327. Health Psychology (4)
An overview of the topic of health psychology. The course presupposes a preventative intervention approach to the problem of assisting healthy individuals to understand the relationship between behavior and health, and to engage those behaviors that promote health. This course will be underpinned with basic science and research on health psychology, but will include an application focus. Prerequisite: Psyc 110. (SS)

Psyc 331. Humanistic Psychology (4)
The literature of and metaphors underlying the humanistic point of view in psychology. These “models of man” are contrasted with models underlying other modes of psychological inquiry.
Prerequisites: Psyc 153 and consent of department chair. Newman. (SS)

Psyc 333. (SSP 333, PolS 333) Social Psychology of Politics (3)
Political behavior viewed from a psychological and social psychological perspective. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Rosenwein. (SS)

Psyc 335. (BioS 335) Animal Behavior (3)
Discussion of the behavior of invertebrates and vertebrates and analysis of the physiological mechanisms responsible for behavioral actions. Emphasis on perception, environmental stimuli, and adaptive value of special behavior patterns.
Prerequisite: BioS 31 or EES 31 or MBio 101. Itzkowitz. (NS)

Psyc 338 (SpEd 338) Emotional and Behavioral Disorders of Children (3)
Definition, classification, etiology, treatment, and historical perspective of child and adolescent disorders. (SS)

Psyc 351. Cognitive Development in Childhood (4)
Piaget and alternative theoretical approaches. Research on development of memory, comprehension, communication, classification, and social cognition. Prerequisite: Psyc 107, 117, or Cogs 7. Barrett. (SS)

Psyc 354. Personality Assessment (4)
Methods of describing and measuring personality. Observational techniques, interviews, self-report inventories, intelligence tests, and projective tests. Prerequisite: Psyc 153. (SS)
Psych 356. (SSP 356) Seminar in Personality Psychology (4)
Topics in personality psychology: the self, personality consistency, motivation, psychological adjustment. Prerequisite: Psyc 153 or consent of instructor. Williams. (SS)

Psych 358. Seminar in Infant Development (4)
Theories and current research focusing on development in the first two years of life. Topics include cognitive, perceptual, language, social, and emotional development, and methods used in infancy research. Prerequisites: Psych 107 and consent of department chair. Barrett. (SS)

Psych 359. Seminar on Psychological Issues in the Legal System (4)
 Contributions of psychological research to understanding the legal system. Social science data on juries, eyewitnesses, mental illness, and the death penalty will be discussed. Conflicts between psychological and legal approaches will be highlighted. Prerequisites: Psych 110 or consent of instructor. Barrett. (SS)

Psych 361. (SSP 361) Personality and Social Development in Adulthood (4)
Theories and current research. Prerequisite: SSP/Psyc 109 or consent of department chair. Hyland. (SS)

Psych 363. (SSP 363) Personality and Social Development in Childhood (4)
Issues related to social development (e.g., attachment, social competence), social contexts (e.g., family, day care), and personality development (e.g., sex roles, aggression, temperament) from infancy through adolescence. Prerequisite: Psych 107 or consent of instructor. (SS)

Psych 364. Children and Narratives (4)
Examines the complex role of narratives - told to and by children, and enacted by children in play - in children's experience and development. Compares and seeks to integrate different approaches in psychology and other disciplines. In the process, we will also be addressing three basic questions: what is narrative, how is it significant, and how should we study it? Prerequisite: Psych 107. Nicolopoulou. (SS)

Psych 365. Cross-cultural Perspectives on Aging (4)
Social development and cross-cultural aging; psychological and sociological theories of ethnic aging; stratification across the life course, health, family issues, economics, legal and political status of ethnic elderly; focus on Hispanic, Asian, Native, and African Americans. Prerequisite: Psych 109. (SS)

Psych 366. Seminar in Cognitive Aging (4)
Information processing by older adults: perception, attention, memory, speech and text processing and comprehension. The course will also examine the effects on cognitive processing of such diseases as Alzheimer's and Parkinson's. Prerequisite: Psych 109; Psych 117 not required but strongly recommended. (SS)

Psych 373. (BioS 373) Sensation and Perception (3)
Receptor processes of vision, audition, touch, taste, and smell. Psychological dimensions of such processes leading to consideration of perception as characteristic of organisms. Prerequisite: Psych 117 or 176 or 177 or CogS 7. (SS)

Psych 375. (BioS 375) Neuroanatomy of Behavior (3)
Neuroanatomy and neurophysiology of animal and human behavior. Feeding, thirst, sleep, emotions, learning, and psychopathology. Prerequisite: BioS/Psyc 177. Simon, Nyby. (ND)

Psych 382. (BioS 382) Endocrinology of Behavior (3)
Hormonal effects upon animal and human behavior. Emphasis on neuroendocrinology of steroid hormone involvement in reproductive behaviors. Prerequisite: BioS/Psyc 177. Nyby, Schneider, Simon. (NS)

Psych 391. Thesis (3)
Written report: Literature review and design of project in selected area of psychology. Intended for senior majors in psychology only. Prerequisite: consent of the chair. (ND)

Psych 392. Thesis (3)
Execution of project designed in Psych 391. Final report and oral presentation. Prerequisites: Psych 391 and consent of the department chair. (ND)

Psych 393. Independent Research (1-3)
Individual research projects designed and executed in collaboration with faculty sponsor. Regular meetings with sponsor to give progress reports and receive feedback. Student reads relevant literature and writes report in APA format. May be repeated once for credit. Prerequisites: Psych 210 or 161 and consent of sponsor. (ND)

For Graduate Students
The Department of Psychology offers a focused program in Human Cognition and Development leading to the doctor of philosophy degree. The program emphasizes a commitment to research with specializations in cognition, development, and social cognition. Students are trained primarily for positions at universities and in basic or applied research settings.

Requirements for a doctoral degree at Lehigh: The college requires 72 credit hours for a doctoral degree for those entering with a bachelor of arts or bachelor of science degree; 48 credit hours are required for those entering with the master of arts or master of science. All doctoral candidates are required to spend at least one year in residence, i.e., in full-time work toward the degree.

Requirements for a Ph.D. in the Department of Psychology:
Research
All graduate students are expected to be involved in research throughout their graduate careers. There are also several formal research requirements of the program.

First-Year Project. First-year students are expected to choose an adviser and begin to work on a research project as early as possible. A written and oral report of the student's research activities is made to the department.

Master's Thesis. A master's thesis (usually empirical or data­based) is required. An oral presentation of the thesis is made to the department. Students entering with a master's degree may submit their thesis in fulfillment of the departmental thesis requirement with faculty approval.

Doctoral dissertation. This is an original piece of scholarly work usually empirical research, although original theoretical or historical research is possible with faculty approval.

Coursework
Core courses. All students are required to take one-semester graduate core courses in cognitive psychology, developmental psychology, and social cognition.

Psych 411 and 412, Analysis and Design of Experiments. These courses represent a two-semester sequence of theoretical and applied statistics and research methodology.

Psych 400+. Graduate Seminars. Students must take four graduate seminars, at least three of which are offered by the psychology department.

Psych 409, Professional Seminar. A one-credit, one semester course taken in the first semester of graduate study that covers research ethics, proposal writing, and instructional issues.

Teaching
Students are encouraged to participate in teaching as appropriate for their training throughout their graduate years. Normally, students begin as teaching assistants and progress to teaching independently.
Support is available in the form of teaching and research. Survey of fundamental theory and methodologies from artificial intelligence, linguistics, cognitive psychology, philosophy, and neuroscience, as well as salient research problems such as knowledge acquisition and representation, natural language processing, skill acquisition, perception and action, and the philosophical question of intentionality.

**Psyc 434. Seminar in Personality (3)**
Selected topics in personality theory and research, including personality change, the self, personality consistency, and the relationships among thought, emotion, and behavior. Prerequisite: Psyc 406. Williams.

**Psyc 435. Abnormal Psychology (3)**
Theoretical and empirical analysis of issues regarding the nature, measurement, causes, and treatment of various forms of abnormal behavior. Williams

**Psyc 448. Seminar in Psychology of Language (3)**
Topics in language comprehension and production. Content will vary from year to year. Prerequisite: Psyc 403 or consent of instructor. Malt, O'Seaghdha

**Psyc 450. Special Topics in Mathematical Models and Statistics (3)**
Selected topics in the application of mathematics to psychological research. May be repeated for credit. Richter

**Psyc 451. (Educ 451) Theories of Learning (3)**
In-depth study of major classical and contemporary learning theories. Review of experimental research relevant to theories. (Intended for graduate students in the College of Education.)

**Psyc 460. Special Study (1-9)**
Study of some special topic not covered in the regular course offerings. May be repeated for credit.

**Psyc 461. Research Seminar (1-9)**
Original research projects not connected with master's or doctoral theses are designed and executed in collaboration with the faculty. Students meet with the seminar director to critique each other's projects. May be repeated for credit.

**Psyc 471. Applied Psychology Internship (1-6)**
Supervised, independent field work experience in industry, a medical setting, or a mental health setting. May be repeated for up to six hours credit.

**Psyc 473. (CPsyc 475) Personality and Adjustment (3)**
Theories of personality and adjustment with emphasis on the adjustment processes in an educational setting. Prerequisite: consent of the program director.

**Psyc 475. (CPsyc 460) Theories of Psychological Counseling (3)**
Analysis and synthesis of concepts drawn from counseling theorists. Research and current trends in counseling concerning educational, social, and vocational topics. Prerequisite: admission to program in counseling.

**Psyc 476. Seminar in Cognition (3)**
Selected topics in human information processing, including such areas as attention, memory, language and comprehension, and decision-making. Area of emphasis will vary from year to year. Prerequisite: Psyc 403 or consent of instructor. Malt, O'Seaghdha

**Psyc 478. (CogS 478) Ontological Psychology (3)**
Principles and constraints for the modeling of psychological phenomena: perception, memory, knowing, emotions, consciousness, language, and rationality. Bickhard

**Psyc 480. Seminar in Cognitive Development (3)**
Selected topics in cognitive development in infancy and childhood, including such areas as conceptual development,
memory development, the development of reasoning abilities, and language acquisition. Emphasis will vary from year to year.
Prerequisite: Psyc 405 or consent of instructor. Barrett

Psyc 481. Selected Topics in Social and Personality Development (3)
Topics include emotional and sex-role development, peer relations, and social competence. Emphasis will vary from year to year. Prerequisite: Psyc 405 or 474 or consent of instructor.

Psyc 482. Seminar in Adult Development (3)
Application of lifespan developmental theory and methodology to personality, social, and cognitive development in adulthood. Prerequisite: Psyc 405 or consent of instructor. Hyland

Psyc 483. Seminar in Cultural Psychology (3)
Major theoretical approaches and empirical debates in cultural psychology, with a focus on the interplay of individual and sociocultural elements in the formation of mind, the emergence of the self, and the definition and reproduction of culture. Prerequisite: Psyc 405 or 474 or consent of instructor. Nicolopoulou

Psyc 486. Seminar in Clinical Psychopharmacology (3)
Examination of diagnostic issues and pharmacological intervention strategies in the treatment of neuroses, psychoses, and other psychological/psychiatric problems. Emphasis on consideration of current primary references with evaluation through student presentations. Prerequisite: Psyc 404 or consent of instructor. Simon

Public Relations
See listings under Journalism and Communication.

Quality Engineering
Faculty. The Quality Engineering program is offered by the Department of Industrial and Manufacturing Systems Engineering. A list of the faculty can be found in section V of this catalog, under the heading: Industrial and Manufacturing Systems Engineering.

Director. John W. Adams, Ph.D. (North Carolina at Chapel Hill); Professor Emeritus of Industrial and Manufacturing Systems Engineering.

Quality Engineering. A graduate program leading to the master of science degree in quality engineering (MSQE) was started in January 1995. The program is designed to accommodate part-time students who are employed full-time. All courses are offered by satellite so that students whose employers provide down-link equipment can complete all requirements for the degree without coming to campus. To be considered for admission, applicants must have a B.S. degree in engineering (any discipline) or in science.

Program Requirements. University requirements for the master's degree are stipulated in section IV of this catalog under the heading: degree information. All of the general requirements must be satisfied, except for the following: (1) the MSQE does not require a thesis, report or comprehensive examination, and (2) it does not require attendance at Lehigh. The satisfactory completion of 30 credit hours of appropriate coursework satisfies all requirements.

Course Requirements. To complete the program, a student must complete ten three-credit courses. Of the ten courses, five are core courses, required of all students, and five are electives. Three of the elective courses are selected by the student from a prescribed list of courses that the department faculty considers relevant to quality engineering. The last two electives can be any graduate courses that the program coordinator approves. The registrar will consider student requests to transfer credits - a maximum of six credits - from other institutions.

Core Courses. The core of the MSQE program consists of the five courses listed below. These courses must be included in every student's program.

IE 332        Quality Control (3)
IE 328        Engineering Statistics (3)
IE 410        Design of Experiments (3)
IE 422        Measurement and Inspection Systems (3)
IE 442        Total Quality Management (3)

Course descriptions of the core courses can be found in section V of this catalog, under the heading: Industrial and Manufacturing Systems Engineering.

Elective Courses. All students in the program must choose at least three courses from the following list:

IE 305        Simulation (3)
IE 340        Production Engineering (3)
IE 405        Advanced Quality Control (3)
IE 409        Data Dependent Systems (3)
IE 415        Manufacturing Management (3)
IE 421        Nontraditional Manufacturing Processes (3)
IE 424        Robotic Systems and Applications (3)
IE 426        Artificial Neural Networks (3)
IE 448        Industrial Control Systems for Manufacturing (3)
IE 460        Engineering Project (3)
GBUS450       Strategic Supply Management (3)
Math 338      Regression Analysis (3)
ME 446        Mechanical Reliability (3)

Course descriptions of the elective courses can be found in section V, under the heading of the offering department.

Religion Studies
Professors. Norman J. Girardot, Ph.D. (Chicago); Michael L. Raposa, Ph.D. (Pennsylvania); Laurence J. Silberstein, Ph.D. (Brandeis); Philip and Muriel Berman Professor of Jewish Studies, and Director of the Philip and Muriel Berman Center for Jewish Studies; Lloyd H. Steffen, Ph.D. (Brown); Lenore E. Chava Weisler, Ph.D. (Pennsylvania); Philip and Muriel Berman Chair of Jewish Civilization.
Associate professors. Kenneth L. Kraft, Ph.D. (Princeton), Chair; Benjamin G. Wright, III, Ph.D. (Pennsylvania).

The religion studies department is committed to the academic investigation of religion as an intrinsic and vital dimension of human culture. The scholarly study of religion is an integral facet of a liberal arts education. The student of religion is engaged in the critical and interpretive task of understanding patterns of religious thought and behavior as aspects of the human cultural experience.

Religion studies is interdisciplinary in that it draws upon humanistic and social scientific modes of inquiry. These include historical, philosophical, sociological, anthropological, and psychological perspectives. Religion studies is a cross-cultural, comparative discipline concerned with the character and significance of the major religious traditions of the world. The student of religion confronts ethical problems and basic issues of value and meaning raised by modern multicultural and technological society.
**Major in Religion Studies**
The major in religion studies consists of 32 credit hours of coursework (eight courses). Requirements include:
1. At least one introductory course (any course numbered below level 10).
2. At least one course on a Western religious tradition, and at least one course on an Eastern religious tradition.
3. At least four courses at the 100 level or above.
In addition to this minimum distribution, a concentration is recommended in one of the major religious traditions, or in a comparative or thematic approach to the study of religion. The concentration should include at least four courses, where that is possible. Language study appropriate to the concentration is also desirable.

Students are particularly encouraged to consider a joint or double major with another major field from any of the three colleges at the university.

**Departmental Honors**
Religion studies majors are admitted to honors by invitation of the departmental faculty toward the end of the student's junior year. To be eligible, a student must have attained at least a 3.25 average in his or her major program by the end of the junior year. Upon admission to honors, the student will work out a special program of studies for the senior year with the major advisor, culminating in the writing of a senior essay.

**Minor in Religion Studies**
The minor in religion studies consists of a total of 16 credits. The specific courses to be taken by each student are to be decided upon jointly by the student and the departmental advisor. Ordinarily, the student will be expected to take one introductory course unless specifically exempted by the department chair.

**Course Offerings**
Rel 1. Sacred Scriptures from Around the World (4)
An encounter with the different sacred books of the world's major religions. Both the books and differing attitudes in these traditions towards sacred books are examined. Books investigated include the Bhagavad Gita, the Analects of Confucius, the Qur'an and the Jewish and Christian Bibles. Wright. (HU)

Rel 2. Death in Religious Traditions (4)
Introduces students to the study of religion through an exploration of what different religious traditions have to say about the great mystery that we all face, death. Because we all must die, all religions must deal with the challenge and sense of crisis provoked by the deaths of those close to us, of innocent victims of disaster, disease, and crime, and our own imminent deaths. Death thus provides an excellent point of comparison among the various religious traditions. Weissler. (HU)

Rel 3. (Phil 3) Religion and Ethics in Religious Traditions (4)
Introduction to philosophical and religious modes of moral thinking, with consideration given to ethics in the world religious traditions (family life and role of women, social justice, environment, work, models of ethical ideal). Particular issues examined include abortion, capital punishment (such as the death penalty), problems in medical ethics, and heavy drinking as a behavioral problem. Steffen. (HU)

Rel 4. How to Study Religion (4)
How do sociologists, psychologists and philosophers answer such questions as: Why and how do religions arise? Why and how do people develop beliefs in God? Where do religious scriptures come from? Why do people ascribe authority to religious traditions? Why has religious faith declined in modern society? Silberstein. (HU)

Rel 5. Spiritual Exercises East and West (4)
Explores a variety of religious disciplines developed in both eastern and western religious traditions, ranging from the practice of yoga and the martial arts to various forms of prayer, meditation and asceticism. Raposa. (HU)

Rel 6. Religion and the Ecological Crisis (4)
Past and present responses to nature in world religions. Contemporary topics include the animal rights debate, ecofeminism, and the development of environmental ethics. Is “the end of nature” at hand? Why is the environment a religious issue? Kraft. (HU)

Rel 7. Jesus, Buddha, Mao, and Elvis (4)
Comparative and cross-cultural exploration of the nature and meaning of “religious founders” in the history of religions. Girardot. (HU)

Rel 8. (WS 8) Prehistoric Religion, Art, and Technology (4)
Origins and early development of religions, with focus on interactions of religion, art, and technology in the Paleolithic and Neolithic periods. Special attention to the emergence of patriarchal social forms and the figure of the goddess. Interdisciplinary methods with a consideration of feminist theories of cultural development. Girardot. (HU)

Rel 62. (Asia 62) Religions of India (4)
Origin, development and meaning of the major forms of Indian religious traditions. Attention to elite and popular forms of Hinduism, Yoga, early Buddhism. (HU)

Rel 64. (Asia 64) Religions of China (4)
History and meaning of the major forms of Chinese religious—especially Confucianism and Neo-Confucianism, Taoist mysticism, Buddhism (Ch'an / Zen), and popular religion. Girardot. (HU)

Rel 65. (Asia 65) Religions of Japan (4)
A survey of Japan's diverse religious heritage and its impact on contemporary culture. Japanese approaches to the self, the world, and the sacred are considered in comparative perspective. Topics covered include: Shinto, Buddhism, Zen, Confucianism, the way of the warrior, folklore, and postwar movements. Kraft. (HU)

Rel 67. (Asia 67) Japanese Civilization (4)
The history and culture of Japan from its origins to the present. Special consideration will be given to the rise and fall of the warrior class, developments in art and religion, the dynamics of family life, and Japan's “economic miracle.” Kraft. (HU)

Rel 68. Practical Justice: From Social Systems to Responsible Community (4)
Examination of the role of moral and religious values in social systems, including education, the economic system, criminal justice, with particular attention to the problems of poverty, literacy, homelessness and domestic violence. Students engage in volunteer efforts to gain practical experience with those who deliver and receive services in these systems. An action-reflection model (with reference to liberation theology and religious thinkers like M.L. King, Dorothy Day, and Walter Rauschenbusch) is employed to urge reflection on how social systems can be affected and transformed by visions of justice, ethics, religion and social responsibility. Steffen. (HU)

Rel 73. The Jewish Tradition (4)
Development of traditional Judaism; readings in the Bible, the Talmud, and selected mystic texts. Discussions will focus on the diverse ways in which Judaism has been understood and interpreted up until the end of the 18th century. Silberstein, Weissler. (HU)
Rel 75. The Christian Tradition (4)
Introduction to the Christian tradition from its early variety and subsequent classical definition in the church councils up to the enlightenment. Special emphasis will be placed on the multiform interpretations of the Christian message. Wright. (HU)

76. Reading the Bible in the Contemporary World (4)
Reading passages from the Bible with an eye toward distinguishing and understanding different sorts of questions that can be asked of them and various perspectives that can be adopted when reading them. What are these stories about? What do they mean, when, and to whom? Wright. (HU)

Rel 77. (Asia 77) The Islamic Tradition (4)
Origin and development of classical Islam. Topics include Muhammad and the Koran; legal, theological, and ritual institutions; the Caliphate; Islamic mysticism; Islamic cosmology and Islamic science. (HU)

Rel 111. Jewish Scriptures/Old Testament (4)
The religious expression of the Hebrews, Israelites, and Jews as found in the Jewish Scriptures (TANAK/Christian Old Testament). Near Eastern context of Hebrew religion, the religious expression of the Hebrews, Israelites, and Jews as found in the Jewish Scriptures (TANAK/Christian Old Testament). Near Eastern context of Hebrew religion, the

Rel 112. The Beginnings of Judaism and Jewish Origins: Jewish Diversity in the Greco-Roman World (4)
The variety of approaches to Judaism in the period following the Babylonian exile through the second century C.E. The literature studied will include Apocrypha, Pseudepigrapha, and the Dead Sea Scrolls. Wright. (HU)

Early Christianity from its beginnings until the end of the second century. Coverage includes the Jewish and Hellenistic matrices of Christianity, traditions about the life of Jesus and his significance, and the variety of belief and practice of early Christians. Emphasis on encountering primary texts. Wright. (HU)

Rel 121. Sources for the Life of Jesus: the Jewish and Christian Context (4)
Ancient sources that claim to provide information about Jesus of Nazareth. Approaches taken to Jesus' life and career; early Christian interpretations of the significance of Jesus; methodology in assessing evidence for the historical Jesus and his message. Wright. (HU)

Rel 124. (Phil 124) Reason and Religious Experience (4)
A critical look, from a philosophical perspective, at some fundamental problems of religion: The nature of religious experience and belief, reason and revelation, the existence and nature of God, the problem of evil, and religious truth. Raposa. (HU)

Rel 125. Heresy and Orthodoxy: Varieties of Christianity in the First Three Centuries (4)
Examines the development of Christianity until the end of the third century. Compares the views of different groups about the significance of Jesus. Who were the proto-orthodox? Jewish Christians? Gnostics? What did they think? Why were some branded heretics by others? Wright. (HU)

Rel 129. (Phil 129) Jewish Philosophy (4)
How major Jewish thinkers from the first to the 20th centuries confronted questions at the intersection of religion and philosophy: the existence and nature of God, free will, evil, divine providence, miracles, creation, revelation, and religious obligation. (HU)

Rel 132. Hasidic Tales (4)
Examines the mysterious and beautiful tales told by Hasidim, participants in the movement of spiritual revival which arose within 18th century Judaism. Compares Hasidic tales to European fairy tales, and shows how later writers transformed Hasidic narratives to express their own religious or literary meanings. Weissler. (HU)

Rel 133. New Age Spirituality (4)
An exploration of alternative religious beliefs and practices in the late 20th century. Topics include goddess religion, channeling, UFOs, adaptations of Asian and Native American traditions, and spiritual environmentalism. How “new” are New Age religions? How does a genuine religious movement differ from a cult? Kraft. (HU)

Rel 138. (WS 138) Women in Jewish History (4)
Contributions of, and limitations on, women at different stages of Jewish history, using both primary sources and secondary material. Experience of modern Jewish women, and the contemporary feminist critique of traditional gender roles. Weissler. (HU)

Rel 139. (Anth 139) Jewish Folklore (4)
Traditional culture and lore of European Jews from 18th century Central Europe to 19th century Eastern Europe. Shift from folk to ethnic culture as Eastern European Jews emigrated to North America in the 20th century. Nature of tradition and ethnicity; difference made by gender in experiencing traditional culture; relationship between “official” religion and popular traditions. Readings supplemented by films, field trips, and student field work. Weissler. (SS)

Rel 144. Raw Vision: Creativity and Ecstasy in the Work of Shamans, Mystics, and Artist Outsiders (4)
Comparative exploration of the nature and meaning of religious and artistic experience as reflected in shamanism (both prehistoric and tribal), mystic traditions (especially Taoism and Christianity), and contemporary self-taught artistic visionaries (e.g., Jean Dubuffet, Howard Finster, Mr. Imagination, Lonnie Holley, Norbert Kox). Various disciplinary perspectives will be employed including comparative religions, anthropology, art history, and psychology. Girardot. (HU)

Rel 150. Judaism in the Modern World (4)
Fundamental themes in the experience of modern Jewry; confrontation with secular culture; crisis of religious faith; Judaism with individualism, pluralism, and voluntarism. How have the Holocaust and the State of Israel shaped the self-understanding of American Jewry? Silberstein. (HU)

Rel 152. American Judaism (4)
Diverse cultural and social forms through which American Jews express their distinct identity. Is American Jewry an example of assimilation and decline or creative transformation? What, if anything, do American Jews share in common? Compatibility of Judaism with individualism, pluralism, and voluntarism. How have the Holocaust and the State of Israel shaped the self-understanding of American Jewry? Silberstein. (HU)

Rel 154. (Hist 154) The Holocaust: History and Meaning (4)
The Nazi holocaust in its historical, political and religious setting. Emphasis upon moral, cultural and theological issues raised by the Holocaust. (HU)

Rel 155. Jewish Responses to the Holocaust (4)
Since 1945, many Jewish thinkers and writers have attempted to confront such problems as: What is an appropriate Jewish response to the Holocaust? What does it mean to live Jewishly in the wake of the Holocaust? What does the Holocaust indicate
Rel 156. Israel, Zionism, and the Renewal of Judaism (4)
New interpretations of Judaism, the Jewish community and Jewish history developed by Zionist thinkers. Diverse currents within Jewish nationalist thought and critical responses to Zionist ideology. Silberstein. (HU)

Rel 157. (Hist 157) The Renaissance and Reformation (4)
The transition from medieval to modern society. Consideration of political, economic, and social forces produced by the Renaissance and their influence upon the dominant religious theme of the Reformation era. Baylor. (HU)

Rel 158. (WS 158) Sex and Gender in Judaism: The Feminist Critique (4)
Writings by Jewish feminists reflecting the encounter between Judaism and feminism: prayer and ritual, women rabbis, God, and God language, communal power, the marriage and divorce. Silberstein. (HU)

Rel 159. Roman Catholicism in the Modern World (4)
A survey of the various intellectual, cultural, political and ecclesiastical developments that have shaped contemporary Roman Catholic life and thought. Raposa. (HU)

Rel 160. (Asia 160) The Taoist Tradition (4)
Consideration of the religious and cultural significance of Taoism in its various historical forms. Primary attention will be given to a close reading of some of the most important texts of the early philosophical tradition (e.g. Tao Te Ching, Chuang Tzu) and of the later religious tradition (e.g. Pao P'u Tzu and other selections from the Tao Tsang). Contemporary implications of Taoist thought will also be considered (e.g. "The Tao of Physics"). Girardot. (HU)

Rel 161. (Asia 161) Zen Buddhism (4)

Rel 162. (Asia 162) Zen Buddhism (4)

Rel 164. (Asia 164, IR 164) Japan's Response to the West (4)
A survey of Japanese history and culture from 1500 to the present, following the theme of Japan's contact with the West. What enabled Japan to modernize and Westernize so successfully? Topics covered include: the expulsion of Christianity, the first samurai mission to the U.S., the postwar American occupation, and contemporary issues. Readings include Japanese novels and short stories (in translation). Kraft. (HU)

Rel 165. (Asia 165) Engaged Buddhism (4)
Examine a contemporary international movement that applies Buddhist teachings and practices to social, political, and environmental issues. Topics include: important thinkers, forms of engagement, and areas of controversy. Kraft. (HU)

Rel 166. (Asia 166) Buddhism in the Modern World (4)
Explores contemporary Buddhism in Asia, America, and Europe. Topics include the plight of Tibet, Buddhist environmentalism, and the emergence of a socially engaged Buddhism. How are Westerners adapting this ancient tradition to address present-day concerns? Kraft. (HU)

Rel 169. (Asia 169) Classics of Asian Religion (4)
Sacred scriptures of Asia and an introduction to the religions they represent. What do these texts teach about reality, humanity, divinity, and society? How is the path of spiritual practice presented in the different traditions? Kraft, Girardot. (HU)

Rel 174. Contemporary Theology (4)
Major 20th century movements within Christian and Jewish theology understood as responses to the problems of modern times. May be repeated for credit as the subject matter varies. Raposa. (HU)

Rel 180. (Hist 180) Religion and the American Experience (4)
The historic development of major American religious groups from colonial times to the present; their place in social and political life, and the impact of the national experience upon them. Raposa. (HU)

Rel 184. (WS 184) Religion, Gender, and Power (4)
Gender differences as one of the basic legitimations for the unequal distribution of power in Western society. Feminist critiques of the basic social structures, cultural forms, and hierarchies of power within religious communities, and the ways in which religious groups have responded. Silberstein. (HU)

Rel 186. Judaism in Israel and the United States (4)
Explores the differences/similarities in the ideologies, myths and symbols which shape the views of Jews in Israel and the United States on such issues as: the meaning of Judaism, the interpretation of Jewish history, the relationship of religion and peoplehood, and the relationship of democracy and Jewish values. Readings include Amos Oz, A.B. Yehoshua, Haim Hazaz, Leonard Fein, Mordecai Kaplan. Silberstein. (HU)

Impact of the scientific and technological culture on the Western religious imagination. Roots of science and technology in religious ideas and images. Ways of knowing and concepts of experience in religion and science. Raposa. (HU)

Rel 191. Religion and the Visual Arts (4)
Religious themes in the modern novel or the spiritual autobiography. Melville, Tolstoy, Camus, Updike, Walker, and Morrison; or Woolman, Tolstoy, Malcolm X, Wiesel, Frederick Douglass, Sojourner Truth, Kukai. Steffen. (HU)

Rel 192. Religion and the Visual Arts (4)
Religious themes in the modern novel or the spiritual autobiography. Melville, Tolstoy, Camus, Updike, Walker, and Morrison; or Woolman, Tolstoy, Malcolm X, Wiesel, Frederick Douglass, Sojourner Truth, Kukai. Steffen. (HU)

Rel 193. (Clas 213) Ancient Roman Religion (4)

Rel 221. (Asia 221) Topics in Asian Religions (4)
Selected thematic and comparative issues in different Asian religious traditions. May include Buddhism and Christianity, religion and martial arts, Asian religions in America, Taoist meditation, Zen and Japanese business, Buddhist ethics. May be repeated for credit. Girardot. Kraft. (HU)

Rel 222. Topics in Western Religions (4)
Selected historical, thematic, and comparative issues in Judaism, Christianity, and Islam. May be repeated for credit as the subject matter varies. (HU)
Rel 224. (Phil 224) Topics in the Philosophy of Religion (4)
Selected problems and issues in the philosophy of religion. May be repeated for credit as the subject matter varies. Raposa. (HU)

Rel 225. Topics in Religion and Ethics (4)
Analysis of various moral problems and social value questions. Possible topics include: environmental and non-human animal ethics; medical ethics; drug and alcohol abuse; spiritual meaning of anorexia. (HU)

Rel 230. The Mystical Tradition: Judaism (4)
Explores the history of the quest to know God, through mystical experience or theosophical speculation, as found in Jewish tradition. Examines such issues as the tensions between institutional religion and personal religious experience, between views of God and immanent in the world or transcending it, and between imagery of God and religious experience of God. Not open to students who took Rel 130. Weissler. (HU)

Rel 251. (Clss 251) Classical Mythology (3)
Myth, religion and ritual in ancient Greece and Rome. Emphasis on primary sources; introduction to ancient and modern theories of myth. Cross-cultural material. (SS)

Rel 335. (Anth 335) Religion, Symbolism and Cosmology (3)
How human experience is mediated through the use of symbols. Religious and cosmological systems in cross-cultural perspective. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Frankel. (SS)

Rel 355. (Hist 355) European Intellectual History I (3-4)
Major developments in European culture from the late Middle Ages through the 17th century. Late scholasticism, humanism and the Renaissance, varieties of Protestantism, origins of modern science. Baylor. (HU)

Rel 359. (SSP 359) Sociology of Religion (3)
Religion as a central institution in society. Social functions provided by religion, for individuals and for the society as a whole. Social correlates of interindividual differences in religiosity. Religious sects and cults and why they exist in modern society. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

Rel 361. Fieldwork (1-4)
Opportunity for students to work, or observe under supervision, religious organizations or institutions. Consent of chair required. (ND)

Rel 371. Directed Readings (1-4)
Intensive study in areas appropriate to the interests and needs of students and staff. (ND)

Rel 391. Senior Thesis in Religion (4)

Russian

See listing under Modern Languages and Literature.

Russian Studies

Mary A. Nicholas, Ph.D. (Pennsylvania) program director.
Professors. Donald D. Barry, Ph.D. (Syracuse); Arthur E. King, Ph.D. (Ohio State); Rajan Menon, Ph.D. (Illinois); Monroe J. Rathbone professor of international relations, Oles M. Smolansky, Ph.D. (Columbia).

Russian Studies Major
The major in Russian studies is an interdisciplinary program designed to provide students with a broad exposure to the Russian language and to Russian culture. Courses in language, literature, history, politics, foreign policy, and economics, as well as the possibility of study in the republics of the former Soviet Union, are part of the curriculum for this major. The required and elective courses fit in well with a traditional liberal arts education. At the same time, the emphasis on area studies provides students with a focus for their intellectual efforts and a specialization that can be pursued, in graduate school or in a variety of public and private sector careers, after graduation.

The major in Russian studies requires 36 credit hours, distributed as follows:

A. Required Courses

I. Language and Literature: two years of college Russian, course selection based on placement: 16 credit hours.

II. Russian History

Hist 347  Russia to 1855 (4) or
Hist 348  Russia since 1855 (4)

III. Russian Politics and Foreign Policy

PolS 261  Soviet and Post-Soviet Politics (4) or
IR 168  Diplomacy of USSR, 1917-1991 (4)

B. Elective Courses

The student will select at least three courses from the following list:

IR 167  Diplomacy of Russia to 1917 (4)
PolS 218  Seminar in Post-Soviet Politics (4)
Eco 209  Comparative Economic Systems (3)

Any other Russian language and literature courses.

Other courses approved by the director of the program (e.g., relevant courses offered through LVAIC or at other institutions).

Field Study in the former Soviet Union (e.g., faculty-led study trips offered under special topics or approved study abroad programs).

Any substitutes for required or elective courses must be approved by the director of the Russian studies program.

Russian Studies Minor
The minor in Russian studies is an interdisciplinary program designed to provide a broad range of study of the former Soviet Union. It can be considered the beginning of a specialization in the area that can be continued in graduate school, or a useful area of concentration for certain careers after graduation (e.g., foreign service, governmental employment, business, foreign trade, etc.). The program may also be of general interest to nonspecialist students who wish to do focused work on the culture and society of the former USSR.

The minor in Russian studies requires 18 to 20 credit hours of formal course work, chosen in consultation with the program director, Mary Nicholas, Department of Modern Languages and Literature.

Two semesters of college-level Russian based on the student's level of competence;

Any three of the following:

Any one course in Russian literature or literature in translation (4)
PolS 261  Soviet and Post-Soviet Politics (4)
Hist 347  Russia to 1855 (4)
Hist 348  Russia since 1855 (4)
IR 167  Diplomacy of Russia to 1917 (4)
IR 168  Diplomacy of USSR, 1917-1991 (4)
Eco 209  Comparative Economic Systems (3)
PolS 218  Seminar in Post-Soviet Politics (4)
Special topics courses in other areas such as psychology or sociology and anthropology with permission
Field Study in the former Soviet Union for academic credit under special topics (4)
Other courses approved by the director of Russian studies.

School Psychology
See listings under Education.

Science, Environmental and Technical Writing
See listings under Journalism and Communication.

Science, Technology and Society

Stephen H. Cutcliffe, Ph.D. (Lehigh), program director.
Steven Louis Goldman, Ph.D. (Boston), Andrew W. Mellon Professor in the Humanities.

The Science, Technology and Society (STS) program is the product of a continuing intercollegiate effort to create a common ground from which to explore the relations between science, technology, and society: between ideas, machines and values.

The STS program serves as a focal point for a wide range of courses that study the natures of science and technology, and analyze their social and personal implications. It lends coherence and visibility to offerings otherwise dispersed throughout the catalog.

STS Studies Major
The major in science, technology and society studies prepares students for graduate study or for a wide variety of career opportunities including policy analysis, planning, or community relations with public or private sector agencies concerned with the social relations of scientific research and technological innovation. The intrinsically cross-disciplinary character of science-technology-society interactions is reflected in the B.A. requirements. Majors must complete a minimum of 31 credit hours in STS courses, listed below, together with at least 15 credit hours in any traditional academic discipline: engineering, physical or life science, the humanities, or the social sciences. This collateral set of courses should be chosen in consultation with the program director to provide the foundation needed to engage STS studies issues in which that discipline is implicated. The senior seminar and project provide an opportunity for students to integrate the knowledge they have gained and the skills they have acquired, in the course of guided research on a topic of special interest to them. Additional opportunities for student research are available, especially through STS 181: Independent Study.

STS studies is a social science major in the College of Arts and Science, and majors must fulfill the college's B.A. distribution requirements. A detailed description of the STS studies major requirements follows.

Detailed Description of STS Major Requirements
A. Required STS Courses (minimum of 31-32 hours)
STS 11: Technology and Human Values (4)
STS 12: Engineering and Society (4)
Hist 7: The Machine in America (3)

Two additional advanced courses (100 level or higher) from the list of approved STS Studies courses (6-8)
B. Concentration in a complementary discipline (minimum of 15 hours to be chosen in conjunction with STS studies advisor); or approved departmental or interdisciplinary program minor; or double major.
C. Science and Mathematics Requirement. Students must fulfill the college's regular B.A. distribution requirements of at least eight credits in the natural sciences; and at least three credits in mathematical sciences. At least one of the courses in the natural sciences must also include the associated laboratory course. Theses courses should be chosen in consultation with the advisor.

STS Studies Minor
The program also offers a minor in science, technology & society studies which is open to all undergraduates. Students electing the minor must take a set of courses totaling a minimum of 15 hours that includes STS 11: Technology and Human Values and electives chosen from the list of all courses eligible for STS studies which follows below. Students should consult with the program director when selecting courses for either the major or the minor.

Science, Technology and Society Courses
STS 11. Technology and Human Values (4)
Impact of technology on society in relation to ethical problems raised by the exploitation of technological innovations. Illustrations from history, social studies, philosophy, literature, and film. Cutcliffe. (SS)

STS 12. Engineering and Society (4)
An examination, from the perspective of its social context, of engineering as a distinctive problem-solving discipline. The roles of design, modeling, testing, safety analysis, product and client in defining engineering problems and acceptable solutions to them. Goldman, Nagel. (SS)

STS 124. (Jour 124) Politics of Science (3)
Analysis of the multi-dimensional interaction between the federal government and the scientific community. Explores historical growth of the science-government connection, the scientific establishment both past and present, and the role of scientific advice to the White House and Congress. Also examines scientific ethics, public attitudes toward science, science-society interactions and case studies of scientific controversies. S. Friedman. (SS)

STS 141. (Asia 141) Science and Technology Studies in East Asia (4)
The development of science and technology in East Asia with emphasis on Japan and China. Cultural and religious influences, both internal and external, and interactions with the West, as illustrated by the development of bronze technology, ceramics and architecture. Factors in Western and Japanese society that have contributed to the rapid growth of Japanese technology as well as limits to future growth of technology in East Asia. Notis. (SS)

STS 145. (Hist 145) Introduction to the History of Science (4)
The history of modern science, primarily physical and biological, with emphasis on the development of major theoretical models since the 17th century. Goldman (SS)
STS 181. Independent Study (1-4), fall-spring
Prerequisite: consent of the program director. (ND)

STS 221. (MAT 221) Materials in the Development of Man (3)
Development of materials technology and engineering from the stone age to atomic age as an example of the interaction between technology and society. In-class demonstration laboratories on composition and structure of materials. Term projects using archaeological materials and alloys. Course intended for, but not limited to, students in the humanities and secondary science education. Engineering students may not use this course for engineering science or technical elective credit.
Notis. (SS)

STS 323. (Jour 323) Scientific and Environmental Controversies (4), spring
Exploration of controversial scientific and technological topics from the dual perspectives of scientific uncertainty and mass media coverage. Includes discussion of social responsibilities of and interactions among scientists, journalists, and the public. Examines genetic engineering and biotechnology, environmental health risks, and human behavior research, among other timely issues. Concentrates on one or two major controversies for in-depth research projects; topics vary with the semester. S. Friedman (SS)

STS 341. Issues in American Competitiveness: At Home and Abroad (4)
Issues affecting American commercial competitiveness focusing on topics associated with the recent emergence of a new commercial environment in all First World societies. Team taught in a highly interactive setting with industry, public sector, and government experts, in addition to academics from various disciplines and institutions. Students read topical articles and books, participate in team projects and debates, and conduct team research on competitiveness issues they have chosen for a term report. Goldman, Nagel. (SS)

STS 381. Senior Seminar (4)
In-depth study of selected topics in science, technology and society with special attention to methodological issues. Subject matter may vary from semester to semester. Intended for STS majors and minors, but open to others. Prerequisite: STS 11 or consent of program director. Cutcliffe. (SS)

STS 382. Senior Project (4)
Continuation of STS 381. Students conduct and present independent research projects on STS topics of special interest. Prerequisite: STS 381. Cutcliffe. (SS)

Graduate Courses in STS
(Open to undergraduates by petition only.)

STS 481. Readings in Science, Technology and Society (3)
Readings seminar on selected themes and topics in science, technology, and society. May be repeated for credit with permission of the program director.

Other STS courses.
The following courses, appropriate to STS studies, are offered by various departments. Course descriptions may be found under the catalog entry for the individual department. New courses are frequently added to this list and announced in bulletins published by the STS program. For further information, please contact the program director.

Arch 363 / Hist 363 Evolution of Long-Span Bridge Building—Peters
Arch 365 / Hist 365 Evolution of the Modern Building Process —Peters
Asia 141 Science and Technology Studies in East Asia —Notis
Chm 5 Chemistry and National Issues—Schray
Ciss 108 Ancient Technology—Small
Ciss 204 / Arch 204 Ancient City and Society—Small
Csc 252 Computers and Society—Staff
Eco 311 Environmental Economics—Murley
Eco 314 Energy Economics—McNamara
EES 3 Global Environmental Change —Meltzer & Zeitler

EES 11 Environmental Geology—Evenson
Engl 122 Speculative Fiction—Arbur
Engl 187 Themes in Literature: Utopian Literature —Staff
Hist 7 Machine in America—Smith
Hist 31 / Asia 31 History of Japanese Industrialization Since 1800—Cooper
Hist 32 Japanese Industrialization: laboratory —Cooper
Hist 107 Technology and World History—Smith
Hist 111 Engineering in the Modern World—Smith
Hist 145 Introduction to the History of Science —Goldman
Hist 307 History of American Industrial Technology —Smith
Hist 315 American Environmental History—Cutcliffe
IR 34 Society, Technology, & War—Kauffman
IR 344 International Politics of Oil—Barkey
Jour 124 Politics of Science—Friedman
Jour 125 Environment, Public, and Mass Media—Friedman
Jour 323 Scientific and Environmental Controversies —Friedman
Mat 221 Materials in the Development of Man—Notis
Phil 116 Bioethics—Staff
Phil 128 Philosophy of Science—Bearn
Phil 228 Topics in the Philosophy of Science —Goldman
Phil 250 Minds of People and Robots—Staff
PolS 111 The Politics of Environment and Natural Resources—Wurth
PolS 115 Technology as Politics—Wurth
Rel 6 Religion and the Ecological Crisis—Kraft
Rel 8 Prehistoric Religion and Technology —Girardot
Rel 187 Science, Technology, & the Religious Imagination—Raposa
Ssp 160 Medicine and Society—Lasker
Ssp 327 / Jour 327 Mass Communication and Society —Rosenwein
Ssp 367 Sociology of Science—Rosenwein
Thtr 161 Theater Design and Engineering—Milet

Social Psychology
See listings under Sociology and Anthropology.

Sociology and Anthropology

Professors. David B. Small, Ph.D. (Cambridge), chair; Raymond Bell, Ed.D. (Lehigh); Barbara B. Frankel, Ph.D. (Princeton), Emeritus; John B. Gatewood, Ph.D. (Illinois); Roy C. Herrenkohl,
The department houses two disciplines, sociology and anthropology. Sociology is concerned with the study of human beings in relationships with others. Anthropology takes a holistic approach to the study of humans today and in the past, in a global, and comparative, perspective. Together these disciplines encompass the study of the broadest range of human activities, from the comparative examination of widely divergent past and present cultures and societies, to the inner life of individuals as this influences social behavior, to an examination of the most pressing social issues of our time.

The offerings within the department seek to foster self- and societal awareness as well as an understanding of what it means to be human. Instruction within the department also provides students with the necessary analytic skills to understand and conduct social research. To that end, central to the department’s major programs is training in research methods, statistics, and the use of computer applications in social science.

Math 12, Basic Statistics, is highly recommended for students contemplating a major [and/or minor] in this department. While not required, this course should be taken instead of another math course, if possible, to fulfill the college’s distribution requirements. Math 12 will help prepare students for research requirements for this major.

The department offers three bachelor of arts majors: social relations, anthropology, and sociology/social psychology. The three programs are parallel in structure and requirements. Each consists of 38 credit hours of course work: 17 credits of core courses (4-6 introductory level courses and 11 in theory and methodology) and 21 credits of major electives. The social relations major is an interdisciplinary program for students desiring a wider familiarity with social science fields, whereas the anthropology and sociology/social psychology majors are for students desiring more traditional, disciplinary programs of study.

Research Opportunities. It is the explicit aim of the department to involve majors, minors and other interested students in the ongoing research activities of faculty members. Second-semester sophomore, junior and senior students interested in a supervised research experience are encouraged to consult with the department chair or talk with the appropriate faculty member. Course credit can be received for research experience.

Internship Opportunities. The department maintains close, working relationships with a variety of social agencies and institutions in the area. Majors can earn course credit by carrying out supervised work in field settings, e.g., hospitals, private and public agencies devoted to social services, courthouses, prisons, etc. This useful experience allows a student to apply the concepts learned in the classroom to a field setting and to evaluate vocational aspirations and interests.

Senior Thesis. All majors are encouraged to do independent research culminating in a senior thesis; this is especially recommended for students intending to go on to graduate or professional school. The best time to begin discussing possible projects with faculty is during the second-semester of the junior year. The department chair should be consulted for further details.

Departmental Honors. To be eligible for departmental honors, students must have at least a 3.3 GPA in the major. In addition, students pursuing honors must take SR 399 and write a thesis during their senior year. Awarding of departmental honors is contingent on both the quality of the thesis, as judged by a department committee, and the candidate’s GPA at time of graduation.

B.A. Major Programs

Social Relations

Introductory (two introductory courses: one from among Anth 1, 11 or 12; and one from among SSP 5 or 21)
Anth 1 Introduction to Anthropology (4) fall and spring
Anth 11 Sociocultural Anthropology (3) spring
Anth 12 Human Evolution and Prehistory (3) fall
SSP 5 Introductory Sociology (3) fall
SSP 21 Social Psychology (3) spring

Theory and Methodology (11 credits)
SR 111 Research Methods and Statistics (4) fall
SR 112 Computer Applications in Social Relations (4) spring
SR 381 Development of Social Theory (3) fall

Major Electives (21 credits)
Seven additional courses in social relations, with at least four at the 300-level or above. These must be chosen in such a way that, in conjunction with the introductory courses, the student completes at least two courses in each of anthropology, sociology, and social psychology. No more than six credits of individualized study—371, 393, or 399 courses—can be applied toward this requirement.

Anthropology

Introductory (4 or 6 credits)
Anth 1 Introduction to Anthropology (4) fall and spring OR
Anth 11 Sociocultural Anthropology (3) spring, AND
Anth 12 Human Evolution and Prehistory (3) fall

Theory and Methodology (11 credits)
SR 111 Research Methods and Statistics (4) fall
SR 112 Computer Applications in Social Relations (4) spring
SR 381 Development of Social Theory (3) fall

Major Electives (21 credits)
Seven additional courses in anthropology, with at least four at the 300-level or above. (One of these may be a SR, or SSP course.) No more than six credits of individualized study—371, 393, or 399 courses—can be applied toward this requirement.

Social Relations

Introductory (6 credits)
SSP 5 Introductory Sociology (3) fall
SSP 21 Social Psychology (3) spring

Theory and Methodology (11 credits)
SR 111 Research Methods and Statistics (4) fall
SR 112 Computer Applications in Social Research (4) spring
SR 381 Development of Social Theory (3) fall

Major Electives (21 credits)
Seven additional courses in sociology and/or social psychology, with at least four at the 300-level or above. (One of these seven may be a SR or Anth course.) No more than six credits of individualized study—371, 393, or 399 courses—can be applied toward this requirement.

Note: Students majoring in anthropology or in sociology/social psychology can use the following SR courses to fulfill the major electives requirement as if these were Anth or SSP courses, respectively:
SR 365 Internship in Social Relations (1-4)
SR 395 Methods in Observation (3)
SR 416 Quasi-Experimentation and Program Evaluation (3)
SR 461 Seminar in Social Relations (1-4)

Minor Programs

Anthropology: Anth 1, 11 or 12 and 12 additional credits at the 100-level or above in anthropology.
Social Psychology: SSP 21 and 12 additional credits at the 100-level or above, selected from the following courses (as available): 100, 109, 125, 135, 153, 308, 312, 314, 323, 327, 333, 356, 361, 363, 371, 391, 393.
Social Relations: One introductory course (from among Anth 1, 11 or 12, SSP 5 or 21) and 12 additional credits at the 100-level or above, with at least three credits in each of anthropology, sociology, and social psychology.

Sociology: SSP 5 and 12 additional credits at the 100-level or above, selected from the following courses (as available): 100, 103, 141, 152, 160, 162, 165, 325, 326, 341, 351, 355, 359, 364, 366, 370, 371, 373, 374, 379, 393.

Undergraduate Courses
SR 41. (WS 41) Human Sexuality (3)
Sexuality and gender roles across the life cycle, including human reproduction, decision-making, and the societal regulation of sexual behavior. (ND)

SR 42. (WS 42) Sexual Minorities (3)
How minority sexual identities have been the subject of speculation, misunderstanding, and sometimes violent attempts at correction or elimination. Sexual orientation, gender role, including transvestism and "drag," transsexualism, sexism, heterosexism, and homophobia. Emphasis on critical thinking, guest speakers, and discussions. (SS)

SR 100. Seminar in Social Relations (1-4)
Topics in social relations. May be repeated for credit. (SS)

SR 111. Research Methods and Statistics (4) fall
Research skills in anthropology, sociology and social psychology. Problem formulation; research design; methods and measures; analysis and interpretation of data. Emphasis on the use of statistics in the research process. (ND)

SR 112. Computer Applications in Social Relations (4) spring
Uses of micro- and mainframe computers in the social sciences. Data management; statistical analysis; simulations. Weekly laboratory sessions. Prerequisite: SR 111 or consent of department chair. (ND)

SR 118. Close Personal Relationships (3)
Dynamics of development, maintenance and dissolution of relationships with family, close friends, lovers and spouses. Life cycle of relationships, attraction, communication. (SS)

SR 331. Social Perspectives on Death and Dying (3)
The meaning of the end of life in various societies, especially the United States. Sociological, anthropological, and psychological perspectives of dying as a process, and on death as an event, combined with philosophical and ethical considerations. Topics to be considered include euthanasia and "extraordinary means" to maintain life from neonate to elderly, funeral practices, stages of dying, hospices, and the social milieu and family relationships of the dying person. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SR 363. Seminar in Social Relations (1-4)
Selected social science topics. May be repeated for credit. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SR 365. Internship in Social Relations (1-4)
Supervised work experience and observation in a variety of field settings, e.g., hospitals, social services, public agencies, private organizations. May be repeated once for credit. Prerequisite: open only to the department's majors. McIntosh. (SS)

SR 381. Development of Social Theory (3) fall
Comparative study of social theory. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SR 395. Methods in Observation (3) alternate years
Naturalistic and participant observation in uncontrolled field settings. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Tannenbaum. (SS)

SR 399. Senior Thesis (3)
Research during senior year culminating in senior thesis. Required for social relations majors seeking departmental honors. Prerequisite: consent of the department chair. (SS)

Anthropology
Anth 1. Introduction to Anthropology (4) fall and spring
General introduction to the four subfields of anthropology: biological, archaeological, cultural, and linguistic. Class will center around lectures and discussion of ancillary media. Staff. (SS)

Anth 11. Sociocultural Anthropology (3) spring
Human behavior in cross-cultural perspective. Variations in kinship reckoning, political organization, economic and religious life in comparative perspective. Particular non-Western peoples; films and readings. (SS)

Anth 12. Human Evolution and Prehistory (3) fall

Anth 100. Seminar in Anthropology (1-4)
Topics in anthropology. May be repeated for credit. (SS)

Anth 112. (Clss 112) Doing Archaeology (3)
Principles of archaeological method and theory. Excavation and survey methods, artifact analysis, dating techniques, and cultural reconstruction. Course includes field project. Small. (SS)

Anth 121. (Clss 121) Environment and Culture (3)
Impact of environment upon cultural variability and change. Comparative study of modern and past cultures and their environments as well as current theories of human/environmental interaction. Small. (SS)

Anth 123. (WS 123) The Cultural Construction of Gender (3)
Comparative study of the meanings and social roles associated with gender. Psychological, symbolic, and cultural approaches. Tannenbaum. (SS)

Anth 125. Anthropology of Peasant Peoples (3)
Comparative study of peasants—peoples who depend on small-scale agriculture and comprise 80% of the world population. Cultural, political, and economic bases of peasant societies and their future prospects. Tannenbaum (SS)

Anth 127. (Clss 127) Early Civilization (3)
Introduction to early civilizations in the Near East, Mediterranean, Africa, Europe, and New World. Similarities and differences in economics, politics, social organization, and religion. Small. (SS)

Anth 128. Urban Ethnology (3)
Cross-cultural study of the city as a social milieu. Comparison of methods and strategies for research in urban settings, and the explicit and implicit theories of urban life associated with these. Field projects will use Bethlehem's South Side as an ethnographic laboratory. (SS)

Anth 132. Analysis of Archaeological Materials (4) fall
Analysis of archaeological materials emphasizing technological,
stylistic, and functional aspects of lithic and ceramic artifacts;
background to classification, measurement techniques, generating
databases, and classic analytic procedures. Teltser. (SS)

Anth 139. (Rel 139) Jewish Folklore (4)
Traditional culture and lore of European Jews from 18th century
Central Europe to 19th century Eastern Europe. Shift from folk
to ethnic culture as Eastern European Jews emigrated to North
America in the 20th century. Nature of tradition and ethnic;
difference made by gender in experiencing traditional culture;
relationship between "official" religion and popular traditions.
Readings supplemented by films, field trips, and student field
work. Weissler. (HU)

Anth 140. (CogS 140, Psyc 140, MLL 140) Introduction to
Descriptive Linguistics (3)
Relationship between language and mind; formal properties
of language; language and society; how languages change over
time. (SS)

Anth 145. Human Evolution (4)
The principles of biological anthropology and archaeology as
integrated through the biological and cultural evolution of the
human species. Topics include elements of modern evolutionary
theory emphasizing inheritance and evolutionary processes,
nonhuman primate diversity and behavior, the relationship
between biology and behavior in evolutionary terms, the
hominid fossil record, and the early archaeological record.
Prerequisite: Anth 1, or department permission. (SS)

Anth 151. Utopias and Alternative Communities (3)
Present and past searches for new forms of community in fact
and fiction. (SS)

Anth 172. North American Archaeology (3) fall
Development of prehistoric North American indigenous
population north of Mexico, beginning with earliest evidence of
people in the New World continuing up through European
contact. Teltser. (SS)

Anth 174. (Clss 174, Art 174, Arch 174) Greek Archaeology (3)
Ancient Greek culture from the neolithic to hellenistic periods.
Reconstructions of Greek social dynamics from study of artifacts.
Small. (SS)

Anth 176. (Clss 176, Art 176, Arch 176) Roman Archaeology (3)
Cultures of the Roman Empire. Reconstructions of social,
political, and economic dynamics of the imperial system from
study of artifacts. Small. (SS)

Anth 178. Mesoamerican Archaeology (3)
Ancient civilizations of Mesoamerica: Olmec, Zapotec, Maya,
Teltser, and Aztec. Reconstructions of urban centers, political and
economic organizations, and religions of Australian, Melanesian,
Polynesian, and Micronesian peoples. Gatewood. (SS)

Anth 187. (Asian Studies 187) Peoples of Southeast Asia (3)
Peoples and cultures of Burma, Laos, Cambodia, Thailand,
Malaysia, Singapore, Indonesia, and the Philippines. World view,
religion, economy, politics, and social organization.
Tannenbaum. (SS)

Anth 305. Anthropology of Fishing (3)
Comparative study of fishing peoples and their technologies.
Fishing strategies, control of information, and social
organization of marine exploitation in subsistence and modern
industrial contexts. Theory of common-property resources and
the role of social science in commercial fisheries management.
Prerequisite: Any one of the following introductory courses:
Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department
permission. Gatewood. (SS)

Anth 321. Anthropology of Physical and Mental Health (3)
Definition and treatment of physical and mental health in cross-
cultural perspective. Strategies for coping with illness in literate
and nonliterate, Western and non-Western societies.
Prerequisite: Any one of the following introductory courses:
Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department
permission. (SS)

Anth 325. Economic Anthropology (3)
Cross-cultural perspectives on the ways people produce,
distribute, and consume goods; how these systems are
organized; and how they are connected with other aspects of
society, particularly political and ideological systems.
Prerequisite: Any one of the following introductory courses:
Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department
permission. Tannenbaum. (SS)

Anth 330. Food for Thought (3)
Symbolic and cultural analyses of foods and cuisines. Examines
what people eat, who prepares it, what it means, and the social
and religious uses of foods historically and cross-culturally.
Tannenbaum. (SS)

Anth 335. (Rel 335) Religion, Symbolism and Cosmology (3)
How human experience is mediated through the use of symbols.
Religious and cosmological systems in cross-cultural perspective.
Prerequisite: Any one of the following introductory courses:
Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department
permission. (SS)

Anth 339. Seminar in Anthropology (3)
Topics in anthropology. Varying semester to semester: human
evolution, politics and law, introduction to linguistics, human use
of space, anthropology of deviance. May be repeated for credit.
Prerequisite: Any one of the following introductory courses:
Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department
permission. (SS)

Anth 345. (Clss 345) Evolution of the State (3)
Theories of state formation. Comparison of evolutionary
trajectories of early states in the Near East, Mediterranean, and
New World. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, or department permission. Small. (SS)

Anth 363. Kinship, Marriage and Descent (3)
Kinship as the central institution in primitive social organization.
Variations in definition and regulation of marriage and descent
in cross-cultural perspectives. Critiques of Murdock, Levi-
Strauss, and Fortes. SSP 364 recommended in conjunction with
this course. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department
permission. Gatewood. (SS)
Anth 371. Special Topics (1-3)  
Advanced work through supervised readings. May be repeated for credit. Prerequisite: consent of the department chair. (SS)

Anth 376. Culture and the Individual (3)  
Concepts and methods of studying relations between the individual and the sociocultural milieu. Culture and personality language and thought, cross-cultural studies of cognition. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Gatewood. (SS)

Anth 382. Theory and Method in Archaeology (3)  
Spring  
Archaeological approaches to behavioral reconstruction and explanation of cultural change as manifest in the archaeological record. Overview of the major schools of thought in Europe and North America during the 20th century. Prerequisite: Anth 112. Small and Teltser. (SS)

Anth 392. Field School in Archaeology (6)  
Summer  
Methods and techniques in the recovery of archaeological information including sampling, survey, controlled surface collection, interpretation of aerial photographs, and excavation. Location varies according to research project of instructor. Prerequisites: permission of instructor. Small and Teltser. (SS)

Anth 393. Research Apprenticeship (3-4)  
Conducting anthropological research under the supervision of a faculty member. May be repeated for credit. Prerequisite: consent of the department chair. (SS)

Anth 399. Senior Thesis (3)  
Research during senior year culminating in senior thesis. Required for anthropology majors seeking departmental honors. Prerequisite: consent of the department chair.

Society and Anthropology

SSP 5. Introductory Sociology (3)  
Fall  
Introduction to the sociological perspectives on human behavior and social life. Examines theories and research exploring patterns of relationships between individuals and society, the effects of social structure, culture, and social change on individuals, including the impact of social class, race, and gender. (SS)

SSP 21. (Psyc 21) Social Psychology (3)  
Spring  
Theories, methods of investigation, and results of research in social psychology with emphasis on psychological processes in social behavior, social attitudes, group behavior and social interaction. (SS)

SSP 100. Seminar in Sociology and Social Psychology (1-4)  
Topics in sociology and social psychology. May be repeated for credit. (SS)

SSP 103. (AAS 103) Sociological Perspectives on Racial and Ethnic Communities (3)  
Fall  
The objective of this course is to introduce students to the sociological and historical foundations of the meaning of “race and ethnicity,” and the role these identities play in our understanding of economic, political, and social inequality. Although the course focuses primarily on the U.S., the student is also encouraged to consider the racial and ethnic organization of human societies and collectivities as a global phenomenon. Washington. (SS)

SSP 109. (Psyc 109) Adulthood and Aging: (3)  
Fall  
Social science approaches to the latter two-thirds of the life. Cognitive and personality development; attitudes toward aging; social behavior of older adults; widowhood; retirement. Prerequisite: Psyc 1 or SSP 21 or consent of instructor. Hyland. (SS)

SSP 125. (Psyc 125) Social Psychology of Small Groups (3)  
Theories and empirical research regarding interpersonal behavior in small groups. Classroom exercises and group simulations. Prerequisite: consent of instructor. Rosenwein. (SS)

SSP 135. (Jour 135, Psyc 135) Human Communication (3)  
Processes and functions of human communication in relationships and groups. Rosenwein. (SS)

SSP 141. Social Deviance and Social Control (3)  
Analysis of deviant social systems, supporting factors maintaining them, and societal responses to deviant roles and collectivities. McIntosh. (SS)

SSP 152. Alcohol, Science and Society (3)  
Alcohol use and abuse, its historical function in society, moral entrepreneurship, status struggles and conflict over alcohol. Current problems with attention to special population groups and strategies for prevention of alcohol abuse. McIntosh. (SS)

SSP 153. (Psyc 153) Personality (4)  
Review and critique of theories of personality and their associated systems of psychotherapy. Prerequisite: Psyc 1 or SSP/Psyc 21. (SS)

SSP 160. Medicine and Society (3)  
Health, illness, and the health professions from the sociological perspective. Social epidemiology, social psychology of illness, socialization of health professionals, organization of health care, patient-professional relationships and ethical issues in medical care. Lasker. (SS)

SSP 162. AIDS and Society (3)  
Impact of the AIDS epidemic on individuals and on social institutions (medicine, religion, education, politics, etc.); social and health policy responses; international experience; effect of public attitudes and policy on people affected directly by AIDS. (SS)

SSP 165. Contemporary Social Problems (3)  
Studies of major problems facing contemporary society. (SS)

SSP 166. (AAS 166) Who Gets What?: The Social Problems of Wealth and Inequality (3)  
Considers the existence of poverty amid affluence in the United States. Comparative studies of wealthiest and poorest among us, focusing on social values and social conditions, gender, race, immigration status. Sociological and historical analysis through debate on the causes of social problems related to the gap between the “Haves” and “Have-nots.” Washington. (SS)

SSP 308. (Psyc 308) Seminar in Social Psychology (3)  
Intensive consideration of selected topics in current theory and research in social psychology. The subject matter varies from semester to semester, and includes such topics as the social psychology of education, the applications of perception and learning theory to social psychological problems, the social psychology of science, and the social environment of communication. May be repeated for credit. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SSP 310. (AAS 310, WS 310) Gender, Race, and Sexuality: The Social Construction of Differences (3)  
This course will provide the student with an opportunity to engage current debates about the meaning and use of racial and sexual classification systems in society. Using a multidisciplinary and critical approach, we will examine the historical and sociological contexts in which specific theories of racial and sexual differences emerged in the U.S. Prerequisite: SSP 103, or department permission. Washington. (SS)
SSP 312. (Psyc 312) Interpersonal Behavior in Small Groups (3)
Intensive consideration of theoretical and methodological issues in the analysis of the development of small groups. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Rosenwein. (SS)

SSP 314. Attitudes, Attributions, and Actions (3)
Social perception and cognition as studied in current social psychology. Persuasion, conformity, prejudice, stereotypes, and other social processes in relation to attitude formation and change. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Rosenwein. (SS)

SSP 316. (Psyc 316) Seminar in Personality Psychology (4)
Topics in personality psychology: the self, personality consistency, motivation, psychological adjustment. Prerequisite: SSP / Psyc 153 or consent of instructor. Williams. (SS)

SSP 319. (Rel 319) Sociology of Religion (3)
Religion as a central institution in society. Social functions provided by religion, for individuals and for the society as a whole. Social correlates of interindividual differences in religiosity. Religious sects and cults and why they exist in modern society. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SSP 321. (Psyc 321) The Child in Family and Society (3)
Influences such as marital discord, family violence, poverty and prejudice on the development of the child from birth through adolescence. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SSP 325. (Hist 325, WS 325) History of Sexuality and the Family in the U.S. (4)
Social change from early agrarian communities to beginnings of industrialism, emphasizing socio-economic class, family structure, and treatment of women and minority groups. Shade, Soderlund. (SS)

SSP 326. (Hist 326) Social Class in American History (4)
Changing role of women, minority groups, and the family during the industrial era. Development of the modern class structure and the impact of the welfare state. Prerequisite: any one of the following: Hist 10, 137, 138, or 139, or consent of history department chair. Simon. (SS)

SSP 327. (Jour 327) Mass Communication and Society (3)
A review of theories and research on the relationship of mass communication to social processes. Intensive analysis of selected media products (e.g., TV news, dramas, and sitcoms; films; print; music videos, etc.). Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Rosenwein. (SS)

SSP 333. (PolS333, Psyc 333) Social Psychology of Politics (3)
Political behavior viewed from a psychological and social psychological perspective. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Rosenwein. (SS)

SSP 341. (WS 341) Women and Health (3)
Relationships of women to the medical system. Influence of medicine on women's lives and the impact of the women's movement on health care. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Lasker. (SS)

SSP 351. (WS 351) Gender and Social Change (3)
Changes in gender roles from social psychological and structural perspectives. Comparative analyses of men and women (including people of color) in the social structure; their attitudes and orientations toward work, family, education, and politics. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Spade. (SS)

SSP 355. Sociology of Education (3)
Education as a social institution. Statuses, roles, and relationships in the organization of schools; higher education as well as elementary and secondary schools. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Spade. (SS)

SSP 356. (Psyc 356) Seminar in Personality Psychology (4)
Topics in personality psychology: the self, personality consistency, motivation, psychological adjustment. Prerequisite: SSP / Psyc 153 or consent of instructor. Williams. (SS)

SSP 359. (Rel 359) Sociology of Religion (3)
Religion as a central institution in society. Social functions provided by religion, for individuals and for the society as a whole. Social correlates of interindividual differences in religiosity. Religious sects and cults and why they exist in modern society. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SSP 361. (Psyc 361) Personality and Social Development in Adulthood (4)
Theories and current research. Prerequisite: SSP / Psyc 109 or consent of Psychology department chair. Hyland. (SS)

SSP 363. (Psyc 363) Personality and Social Development in Childhood (4)
Issues related to social development (e.g., attachment, social competence), social contexts (e.g., family, day care), and personality development (e.g., sex roles, aggression, temperament) from infancy through adolescence. Prerequisite: Anth 107, or consent of instructor (SS)

SSP 364. (WS 364) Sociology of the Family (3)
Sociological analysis of families in the United States, including investigations of historical and contemporary patterns. Issues addressed include parenting, combining work and family, divorce and remarriage, family policies. Anth 363 is recommended in conjunction with this course. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Spade. (SS)

SSP 366. Sociology of Aging (3)
Residential patterns, social policies and services for the aged. Alternative political strategies, health programs, living arrangements and workplace choices considered. The changing roles of the elderly in American and other societies, and the special problems they face. Impact of changing age structure. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Lasker. (SS)

SSP 367. Sociology of Science (3)
Review of sociological, social psychological, and anthropological perspectives on science as a cognitive and social enterprise. Analysis of past and contemporary case studies as well as experimental/simulation research. Rosenwein. (SS)

SSP 370. Juvenile Delinquency (3)
The development of delinquent behavior within its social context; an analysis of delinquent gangs and subcultures and the variable patterns of antisocial activity; and the evaluation of institutional controls and treatment of the problem. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Bell. (SS)

SSP 371. Special Topics (1-3)
Advanced work through supervised readings. May be repeated for credit. Prerequisite: consent of the department chair. (SS)

SSP 373. Seminar in Sociology (3)
Intensive consideration of selected topics in contemporary theory or research in sociology. The subject matter varies from semester to semester. May be repeated for credit. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)
SSP 374. Social Stratification (3)
Social inequality as an organizing principle in complex societies. Theories of wealth, class, and power. Sociological impact of education, occupation, and income on social status and social class. Prerequisite: Any one of the following introductory courses: Anth 1, Anth 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SSP 379. (AAS 379) Race and Class in America (3)
This course focuses on the ways in which various categories and groupings within the social concepts of “race” and “class” have organized the American social, economic and political structure and shaped national and international policy. An overview of the distribution of wealth and political power in the United States provides the student with the opportunity to consider how and why “race” and “class” both together and separately can be used to explain racism, residential segregation, poverty, working class identity and the existence of a wealthy power elite in the United States. Prerequisite: SSP 103, or department permission. Washington. (SS)

SSP 391. Evaluation Research (3)
Application of social research methods of evaluation of the effectiveness of social programs. Measurement, research design, criteria of effectiveness and decision making. Prerequisite: SR 111 or SR 112 or consent of department chair. Herrenkohl. (SS)

SSP 392 Teamwork and Leadership (3)
This course focuses on how teams function in organizational settings, especially in business and industry. Consideration is given to team dynamics and the style(s) of leadership needed to establish and lead teams. Emphasis is placed on both the internal workings of teams and on the external relationships that teams have in organizational settings. Research and theory are drawn from a variety of perspectives and disciplines including social psychology, sociology, and management. Case studies from business and industry are examined. Herrenkohl. (SS)

SSP 393. Research Apprenticeship (3-4)
Conducting sociological or social psychological research under the supervision of a faculty member. May be repeated for credit. Prerequisite: consent of the department chair. May. (SS)

Some scholars believe that “historians and sociologists don’t speak the same language.” However, contemporary social questions about cohabitation, marriage, the family, national politics, race and gender relations, immigration and schooling in the U.S. cannot be answered fully without the benefit of historical analysis. This seminar in applied social research will provide advanced students with both the quantitative and qualitative skills to investigate various topics in 19th and 20th century American social and economic structure. Washington. (SS)

SSP 399. Senior Thesis (3)
Research during senior year culminating in senior thesis. Required for sociology/social psychology majors seeking departmental honors. Prerequisites: declared major in sociology/social psychology and consent of the department chair.

Graduate Courses in Sociology
The Master's Program in Sociology prepares students to apply sociological and social psychological perspectives and methods to the analysis of social problems. Grounded in a strong theoretical and substantive understanding of social institutions, social relations, and social policy, as well as in advanced research and computer skills, students are prepared to be effective and experienced practitioners in the field of applied social research. Specialty areas include: policy studies (health, education, family, diversity, substance abuse, delinquency); human communication (teamwork in organizations, interactional processes, mass communication, personal relationships); and program evaluation.

The program requires 30 hours of course work. Required courses are: Advanced Research Methods; Statistics; Proseminar in Applied Social Theory; Advanced Computer Applications; Research Practicum, either in an agency or firm in the community or with a faculty member; and three electives. All students take a comprehensive exam. Students choose whether to write a thesis or to take an additional six credits of elective courses.

SR 401. Proseminar in Applied Social Theory (3)
Theoretical perspectives in sociology and their applications to social issues and policy. Issues may include interpersonal dynamics in groups, leadership and team building, race and gender, AIDS and sexuality, organizational structure and process, addictions policy, educational reform. Staff.

SR 411. Advanced Research Methods (3)
Study of quantitative and qualitative methodologies, measurement and research design issues at an advanced level. Specific methodologies include participant observation, survey, interview, laboratory or field methods, content analysis, and focus groups. Prerequisite: SR 111 or equivalent. Staff.

SR 413. Research Practicum (3-6)
Supervised research, either with a faculty member or in a community agency, designed to apply research skills to a particular problem as defined by the faculty member or agency in collaboration with the student and supervising instructor. Final paper should demonstrate theoretical understanding, proper application of methodology and data analysis, and results of the project. Staff.

SR 414. Survey Research (3)
Examination of survey methods, sample design, interview design, training of survey personnel, data management and analysis.

SSP 415. Case Studies of Social Control (3)
Social control leads to social order and also generates social deviance. The processes involved in this dual production are found in the formal institutions of society and in the informal patterns of interaction within groups. Macro and micro level approaches are explored, especially in the drug and alcohol area. McIntosh.

SR 416. (Edu 416) Quasi-Experimentation and Program Evaluation (3)

SSP 436. Implications of Sociological Research for Educational Policy (3)
This course examines sociological research relevant to current educational policy issues. Topics include urban education, structural reforms, retention, grouping practices, and others. These issues are examined from different micro and macro sociological perspectives. Spade.

SSP 453. Urban Communities (3)
Reading of classical and contemporary urban theory and community studies in sociology and anthropology. Examination of patterns of social class, power, and social change in urban settings, community organizing and public policy aimed at addressing urban social problems, and evaluation of community interventions. Lasker.
SR 461. Seminar in Sociology (1-4)
Topics vary.

SSP 467. Historical Sociology (3)
Research seminar in historical sociology that incorporates both quantitative and qualitative methods to study issues related to population, gender, race, nativity, schooling, and national identity in late 19th and early 20th century United States. Washington.

SR 470. Social Theory (3) fall
Major trends in social science theory in historical context. Comparison of the major theoretical perspectives with an emphasis on underlying philosophy and the development of critical capacities in students.

SR 471. Special Topics (1-3)
Intensive study in an area of sociology that is appropriate to the interests and needs of staff and students.

SR 472. Special Topics (1-3)
Continuation of SR 471.

SR 473. (Edu 473) Social Basis of Human Behavior (3)

SSP 476. Issues in Health Policy Analysis (3)
Sociological analyses of health care and health policy issues of current concern in American and other societies. Application of analytic frameworks to several major issues such as organization and financing of services, effects of aging populations on needs, impact of new diseases and of new technologies. Students will analyze selected health care problems faced by local communities. Lasker.

SR 477. Advanced Computer Applications (3) spring
Uses of computers in social sciences, including data collection, management, and analysis, simulations, and decision-making; includes weekly lab.

SR 490. Master’s Thesis

SSP 492. Advanced Teamwork and Leadership (3)
Examines the development and functioning of teams in the workplace. Includes the purpose of teams, team structure and process, team activities such as decision-making and problem-solving, the organizational context for teams, strategies for implementing teams, and styles of effective team leadership. Research results and case studies are examined. Students participate in illustrative team activities. Herrenkohl.

SR 495. Methods in Observation (3)
Naturalistic and participant observation in uncontrolled field settings. Students will carry out a field project. Tannenbaum.

Spanish

See listings under Modern Languages and Literature.

Special Education

See listings under Education

Speech

See listings as Communication under Journalism and Communication.

Statistics

See listing under Mathematics

Technology, Interdisciplinary Courses

See listings under Science, Technology and Society.

Theatre

Professor. Jeffrey Milet, M.F.A. (Yale); Augustine Ripa, M.F.A. (Northwestern).
Associate professor. Pam Pepper, M.F.A. (Ohio), chair.
Assistant professors. Drew Francis, M.F.A. (Brandeis); Erica Hoelscher, M.F.A. (Northwestern); Kashi Johnson, M.F.A. (University of Pittsburgh).
Adjunct assistant professor. Corinne Butler, BFA (University of IL-Urbana-Champaign); Jennie Gilrain, B.S. (Allegheny College), (Western Michigan University), Professional Training (Jacques Lecoq International School of Theatre, Paris); E. Laura Hausmann, B.F.A. (Boston Conservatory); David Kasten, M.F.A. (Rutgers University); Gerry Kasten, M.F.A. (University of Illinois); Raymond Saraceni, M.A. (Villanova University).

To study theatre is to examine its many internal disciplines. Acting and directing combine with design, technical theatre, dramatic literature and theatre history to form the body of our art. Students may pursue general theatre studies or focus on particular areas such as performance, design or history and literature. They may major in theatre, minor in theatre or participate strictly in our production program. Students may even complete a minor in theatre from outside the College of Arts and Sciences.

The bachelor of arts degree in theatre is granted after at least 39 credit hours of study. Because it is believed that undergraduate theatre education should be broad based with an emphasis on diversity of experience, students are encouraged to take a variety of courses outside the major. Many students complete double majors. Those with the talents and aspirations for a career in theatre have gone to graduate schools offering intense, pre-professional training. Other majors who have not pursued a theatrical career have gone from our program directly into careers in business, social services, sales. Theatre study is an excellent preparation for vocations in which self presentation is important, such as law. The problem solving, analytical and interpersonal skills gained from this discipline are applicable across a wide range of careers. An understanding and appreciation of the complex art of the theatre will enrich a lifetime.

The department’s active production program is curricular and promotes collaborative projects involving students, faculty, staff and guest artists. Our main performance facility is the Diamond Theater, a 300-seat thrust theatre housed in the Zoeller Arts Center. The core of our work in this space is dedicated to productions featuring primarily student actors directed by faculty or guest artists. When possible, a highly qualified student may direct or design in the main space. In addition to our own productions, we regularly invite outside professional performers and ensembles to work with us and perform. We also operate a lab theatre (Zoeller’s Black Box Theater) for student and faculty experimentation. The availability of valuable hands-on experience and the very close working relationships developed between students and faculty uniquely characterize the department of theatre. The department enjoys a special
relationship with Bethlehem's professional theatre company, Touchstone Theatre. Performance and administrative internships with the company are available to qualified students and the department and Touchstone often collaborate on workshops and seminars.

Students interested in designing a major or minor in theatre should consult with the department chair. Experienced theatre students with questions regarding accurate placement in any theatre course should, likewise, consult with the chair.

The Department of Theatre is accredited by the National Association of Schools of Theatre.

Theatre Major
Through the selection of appropriate electives, students may concentrate their major in one of these areas:

- Acting / Directing
- Design / Technical Theatre
- Theatre History / Dramatic Literature
- General Theatre Studies

The major in theatre consists of 39-44 hours distributed as follows:

**Coursework required of all majors, 19-20 hrs**

- Thtr 60 - Dramatic Action, (4)
- Thtr 127 - The Development of Theatre and Drama from Ritual to Renaissance (4)
- Thtr 128 - The Development of Theatre and Drama from Renaissance to Present (4)
- Thtr 315 - Senior Study (0)

**Production Requirement, eight hrs**

Four active semesters of approved production activity, including Thtr 67, Stagecraft (2), Thtr 68, Costume Construction (2) and other approved production-oriented courses.

**Electives, 12-16 hrs**

Four courses carefully selected with an advisor, emphasizing acting / directing, design / technical theatre, theatre history / dramatic literature or general theatre studies.

**Recommended electives from other departments:**
The departments of art and architecture, English, modern languages and literature, music and others all offer courses of value to a theatre major or minor. Consult with your advisor about enriching your academic career outside the theatre department.

Theatre Minor
The minor in theatre consists of at least 22 hours of course work selected in consultation with a departmental advisor. This includes at least five courses (18-20 hrs) and two active semesters in theatre production totaling at least four credits. Fulfill the production requirement through Thtr 67, Stagecraft (2) and/or Thtr 68, Costume Construction (2), or another approved production-oriented course. An approved minor in theatre will include some academic diversity beyond a single curricular area.

**Departmental Honors**
The exceptional student may elect to pursue departmental honors in the senior year. This student must have a GPA of 3.3 in all theatre courses presented for the major. No later than the fall of the senior year the student, with faculty supervision, elects a special project in a particular area of theatre. This may take the form of preparing to direct a play, researching a role to be performed, preparing a design presentation or researching in an area of theatre scholarship in preparation for the writing of a substantial report. In the next semester, usually the spring of the senior year, the report or project would be executed. The student would enroll in two four-credit independent study courses, one each senior semester.

The Acting Sequence
Students with little or no prior acting experience should elect Theatre 11, Introduction to Acting, as their first course. Students with some prior acting experience should consult with the department chair for accurate placement and waiver of the Theatre 11 prerequisite.

**Courses in Theatre**

- **Thtr 1. Introduction to Theatre (3)**
  Foundations of theatre: historical, literary and practical. (HU)

- **Thtr 2. Introduction to Theatre Lab (1)**
  Open only to those concurrently enrolled in Theatre 1. Practical experience in various aspects of play production and theatre management. (HU)

- **Thtr 11. Introduction to Acting (3)**
  Preparation for scene study and characterization. Recommended for students with little or no prior experience. (HU)

- **Thtr 12. Introduction to Acting Lab (1)**
  Open only to those concurrently enrolled in Theatre 11. Practical experience in performance. (HU)

**Theatre Production Courses:** Theatre 20 through 47

Theatre 20 through 47 are open to all undergraduates by permission and/or audition. These production-oriented theatre courses combine classroom investigation with practical application in theatre department, music department and Zoellner Arts Center productions. Unless otherwise noted, they may not be repeated for credit. Consult the academic coordinator in the department of theatre for enrollment information.

- **Thtr 20. Stage Technology and Production I (2)**
  Scene construction materials and techniques. Scenic staging theory, methods and practice. Production assignment in construction and/or crew. Prerequisite: Department permission. (ND)

- **Thtr 21. Stage Technology and Production II (2)**
  Theory, methods and practice for advanced or managerial assignments in construction and/or run crew. Prerequisite: Department permission and Thtr 20. (ND)

- **Thtr 22. Stage Properties and Decoration (2)**
  Creating props and décor for the stage. Production assignment as assistant property master. Prerequisite: Department permission. (ND)

- **Thtr 23. Basic Scene Painting (2)**
  Painting for the stage. Production assignments painting with scenic artist. Prerequisite: Department permission. (ND)

- **Thtr 25. Costume Technology & Production I (2)**
  Costume construction methods and materials. Production assignment in construction or wardrobe. Prerequisite: Department permission. (ND)

- **Thtr 26. Costume Technology & Production II (2)**
  Theory, methods and practice for advanced or managerial assignments in construction and/or run crew. Prerequisite: Department permission and Thtr 25. (ND)

- **Thtr 27. Lighting Technology & Production I (2)**
  Computerized lighting systems. Instrumentation and lighting crew participation. Production assignment in light board operation. Prerequisite: Department permission. (ND)

- **Thtr 28. Lighting Technology & Production II (2)**
  Master Electrician assignment. Prerequisite: Department permission and Thtr 27. (ND)
Study of comedy as a social form through plays of Aristophanes.

State of the art digital audio technology. Production sound assignment, recording, equipment. Production assignment in sound operation. Prerequisite: Department permission. (ND)

Sound Technology & Production II (2) Sound engineer assignment. Prerequisite: Department permission and Thtr 30. (ND)

Performance (2) Performing in a department-approved production. May be repeated for credit. Prerequisite: Department permission. (ND)

Thtr/Mus 37. Scenes from Opera and Musical Theatre (1) Performances in opera and/or musical theatre production. May be repeated for credit. (HU)

Publicity, Press & Public Relations (2) Theory and practice of marketing and public relations for productions. Prerequisite: Department permission. (ND)

Stage Management (2) Organization, scheduling, coordination of various production specialties. Production assignment as assistant stage manager. Prerequisite: Department permission. (ND)

House Management (2) Front of house coordination, audience services, interface with stage management and production team. Production assignment as house manager. Prerequisite: Department permission. (ND)

Greek Tragedy (3) Aspects of Greek theater and plays of Aeschylus, Sophocles, and Euripides in their social and intellectual contexts. Pavlock (HU)

Jazz Dance (2) Jazz dance styles and combinations. May be repeated for credit. Prerequisite: fee, and consent of chair. (HU)

Modern Dance (2) Modern dance styles and combinations. May be repeated for credit. Prerequisite: fee and consent of chair. (HU)

Greek and Roman Comedy (3) Study of comedy as a social form through plays of Aristophanes, Menander, Plautus, and Terence. Pavlock (HU)

Dramatic Action (4) How plays are put together; how they work and what they accomplish. Examination of how plot, character, aural and visual elements of production combine to form a unified work across genre, styles and periods. Recommended as a foundation for further studies in design, literature, or performance. (HU)

Stagecraft (2) Drafting, problem solving, stagecraft, rigging, materials and techniques. Practical experience in executing scenery for the stage. (HU)

Costume Construction (2) Techniques of sewing, pattern drafting and fitting. Practical experience in executing costumes for the stage. (HU)

Stage Electrics (2) Theatre lighting techniques, equipment, materials, methods and theory. Practical experience in executing lighting for the theatre. (HU)

Ballet (2) Classical ballet for beginners and those who have had some training. May be repeated for credit. Prerequisite: fee and consent of chair. (HU)

Design for the Theatre (4) Introduction to the process of creating integrated designs in theatre production. The study and practice of the principles of visual representation, historical and conceptual research and the study of theatrical styles. (HU)

Theatre Sound (2) Techniques, materials, and methods of designing sound for theatrical production. (HU)

Lighting Design (4) An introduction to the art and practice of lighting design for the stage. History of theatrical lighting design. Recommended prior or concurrent course: Thtr 60, Dramatic Action. (HU)

Scene Design (4) An introduction to the art and practice of scenic design for the stage. History of theatrical scenic design. Recommended prior or concurrent course: Thtr 60, Dramatic Action. (HU)

The Development of Theatre and Drama from Ritual to Renaissance (4) Survey of Western theatre and dramatic literature from ritual origins to the Renaissance. (HU)

The Development of Theatre and Drama from Renaissance to Present (4) Survey of Western theatre and dramatic literature from the Renaissance to the present. (HU)

Drafting for the Theatre (4) Theatre drafting techniques and conventions. Material, methods and theory in stage graphics. Model building techniques and practice. An introduction to computer drafting. (HU)

African American Theatre (4) Studies in African American theatre: literary, and practical and historical. May be repeated for credit. (HU)

Directing (4) Introduction to the theatrical director's art. Research, rehearsal techniques, scene work. Prerequisites: Thtr 60, Dramatic Action, and acting experience as determined by the department, or consent of chair. (HU)

Characterization in Realism (4) Elements of characterization through scene study in realistic drama. Recommended for students with some prior acting experience, or Thtr 11. (HU)

Characterization in Expressionism (4) Elements of characterization through scene study in expressionistic drama. Recommended for students with some prior acting experience, or Thtr 11. (HU)

Costume Design (4) An introduction to the art and practice of costume design for the stage. History of theatrical costume design. Recommended prior or concurrent course: Thtr 60, Dramatic Action. (HU)

Stage Make-up (4) Theatrical make-up techniques for the actor and designer. (HU)

Scene Painting I (4) Study and practice of basic and advanced methods of painting for the theatre. Includes basic elements and principles of design, color theory, the influence of light, atmosphere and aesthetics for the theatre. (HU)
Thtr 161. (Arch 161) Theatre Design and Technology (4) 
Designing theatres. Theatre equipment systems and acoustics. Function and form. (HU)

Thtr 175. Special Projects (2-4) 
Theatrical topics of current or special interest. Can be repeated for credit. (HU)

Thtr 181. Theatre Management (4) 
Concepts, techniques and practices related to managing the theatrical enterprise. (HU)

Thtr 185. Production Seminar (4) 
Practicum in various approaches to theatre production, e.g. performance ensemble. Prerequisite: audition, or consent of the chair. Can be repeated for credit. (HU)

Thtr 211 (Germ 211). Introduction to German Drama (4) 
Drama as a literary genre; plays from various periods of German literature. (HU)

Thtr 218 (Germ 218). Goethe’s “Faust” (4) 
Study of Goethe’s play with an introduction to the Faust tradition. (HU)

Thtr 236. Acting Presentational Styles (4) 
Elements of characterization and scene study in presentational dramatic literature from classical through post-modern periods. Prerequisite: 100-level acting course, or consent of chair. (HU)

Thtr 238. Advanced Design (4) 
The process of creating integrated designs through aesthetic theory, history of design and studio-based practice. Analysis of whole production processes; interpretation of theatrical experience through visual media. Total production evolution, including playwright’s aim, director’s vision, design concept, rehearsal development and production technology. Prerequisite: Thtr 113 or 115 or 151. (HU)

Thtr 244. Acting Shakespeare (4) 
Monologue, scene study and ensemble work from Shakespeare’s dramatic and poetic canon. Prerequisite: 100-level acting course, or consent of chair. (HU)

Thtr 245. Advanced Directing (4) 
Continuation of Theatre 144. The director’s voice. Supervised practical experience. Prerequisite: Thtr 144. (HU)

Thtr 253. Scene Painting II (4) 
Applied advanced scene painting methods for the theatre. Shop management for the scenic artist. Collaboration with designers and stage technology. Prerequisite: Thtr 153. (HU)

Thtr 271. Playwriting (4) 
The art and practice of writing plays for the stage. (HU)

Thtr 275. Internship (2-4) 
Professionally supervised work in theatres and theatrical organizations in the areas of performance, design, technical theatre, theatre administration and management. May be repeated for credit. Prerequisite: consent of chair. (ND)

Thtr 315. Senior Study (0) 
Seminar for senior theatre majors. Enhancement of current theatre studies while preparing for further theatre studies or activity. Fall only.

Thtr 318. (Fren 318) Drama in the Twentieth Century (3) 
Contemporary French drama with an analysis of its origins and movements. Armstrong. (HU)

Thtr 328. (Eng 328). Shakespeare (4) 
An introduction to Shakespearean drama including comedies, histories, tragedies, and romances. Emphasis on textual study, cultural contexts, and performance strategies. Hawkes, Traister (HU)

Thtr 351. Advanced Special Projects (4-8) 
Independent study in theatre. Prerequisite: consent of the chair. Can be repeated for credit. (HU)

Thtr 361. Research in Theatre Technology (2-4) 
Solving technological problems in theatre. Application of new technologies. May be repeated for credit. Prerequisite: consent of chair. (HU)

Urban Studies

Urban Studies Committee. David Curtis Amidon, Jr., M.A. (Penn State), associate professor of urban studies and director, urban studies program; Richard W. Barsness, Ph.D. (Minnesota), professor of management; Frank T. Colon, Ph.D. (Pittsburgh), professor of political science; Thomas J. Hyclak, Ph.D. (Notre Dame), professor of economics; Roger D. Simon, Ph.D. (Wisconsin), professor of history; J. Bruce Thomas, Ph.D. (Berkeley), associate professor and chair of architecture; Ivan Zaknic, M.Arch. and Urban Planning (Princeton), professor of architecture.

This is an interdepartmental major program intended for students who seek a broad background in the social sciences and for those with career interests in such fields as business or law, and such specialized areas as city management, architecture and urban planning, human relations, and the helping professions.

Instruction focuses on the process of urbanization, the problems and opportunities arising therefrom, the relationship between cities and economic growth, and public policies relating to cities.

A minimum of 37 credit hours is required, apportioned among two levels of study. Substitutions are possible with approval of the director, who advises all those with majors and minors in urban studies. The director’s office is located at 232 Chandler-Ullmann Hall.

Undergraduate Major

I. required preliminary courses (12 credit hours)
US 61 The Study of Urbanization (4)
US 62 Contemporary Urban Issues (4)

one of the following research methods courses
PolS 221 Research in Political Science (4)
Eco 145 Statistical Methods (4)
Hist 202 Introduction to Historical Research (4)
Math 12 Basic Statistics (4)
SR 111 Research Methods of Social Relations (4)

II. elective courses (25 credit hours)
Any course may be elected from among the following:

Eco 312 Urban Economics (3)
Eco 237 Transportation Economics (3)
PolS 177 Urban Politics (4)
PolS 260 Public Administration (4)
Hist 334 American Urban History (4)
SSP 370 Juvenile Delinquency (3)
US 363 Philadelphia: Development of a Metropolis (4)

Up to two Architectural History courses numbered 100 or higher
Up to two courses may be elected from among the following:
Eco 354 Public Finance: State and Local (3)
PolS 231 Government and Law Internship (4)
(PolS 232 may be offered instead of PolS 231)
**Women's Studies**

**Director.** Robin S. Dillon, Ph.D. (Pittsburgh), associate professor of philosophy.

**Professors.** Rosemarie Arbour, Ph.D. (Illinois), professor of English; Jan S. Ferguson, Ph.D. (C.U.N.Y.), professor of English; Elizabeth N. Fifer, Ph.D. (Michigan), professor of English; Edward J. Gallagher, Ph.D. (Notre Dame), professor of English; Lucy C. Gans, M.F.A. (Pratt), professor of art and architecture; Thomas J. Hylack, Ph.D. (Notre Dame), professor of economics; Diane T. Hyland, Ph.D. (Syracuse), professor of psychology; Judith N. Lasker, Ph.D. (Harvard), professor of sociology and anthropology; Laura Katz Olson, Ph.D. (Colorado), professor of political science; C. Robert Phillips, Ph.D. (Brown), professor of history; William G. Shade, Ph.D. (Wayne State), professor of history; Laurence J. Silberstein, Ph.D. (Brandeis), Philip & Muriel Berman Professor of Jewish Studies and professor of religion studies; Jean R. Soderlund, Ph.D. (Temple), professor of history; Lloyd H. Steffen, Ph.D. (Brown), University Chaplain and professor of religion studies; Lenore E. Chava Weissler, Ph.D. (Pennsylvania), Philip and Muriel Berman Chair of Jewish Civilization and associate professor of religion studies.

**Associate professors.** Marie-Helene Chabut, Ph.D. (U.C. San Diego), associate professor of French; Gail A. Cooper, Ph.D. (U.C. Santa Barbara), associate professor of history; Jill E. Schneider, Ph.D. (Wesleyan), associate professor of biological sciences; Joan Z. Spade, Ph.D. (S.U.N.Y., Buffalo), associate professor of sociology and anthropology; Hannah W. Stewart-Gambino, Ph.D. (Duke), associate professor of political science; Nicola B. Tannenbaum, Ph.D. (Iowa), associate professor of sociology and anthropology.

**Assistant professors.** Patricia C. Ingham, Ph.D. (U.C. Santa Barbara), assistant professor of English; Ageliki Nicolopoulos, Ph.D. (U.C. Berkeley), assistant professor of English; John Pettigrew, Ph.D. (Wisconsin), assistant professor of history; Patricia Turner, Ph.D. (Michigan), assistant professor of history; Mary Washington, Ph.D. (Johns Hopkins), assistant professor of sociology and anthropology.

The minor in women's studies engages students in the study of two interrelated subjects. The first is an examination of the cultural, historical, and social experiences and contributions of women. The second is an exploration of gender (the social construction of differential identity for males and females) and of the ways in which gender distinctions shape human consciousness and human society.

Nearly all academic disciplines have defined human nature and significant achievement in terms of male experience and have underestimated the impact of gender on social structures and human lives. By contrast, women's studies courses attend to women's diverse experiences and perspectives and acknowledge the critical significance of gender. By shifting the focus to women and gender, women's studies seeks to provide an alternative paradigm for understanding human experience. Students in women's studies courses are encouraged to reevaluate traditional assumptions about human beings, human knowledge, and human culture and society, and to explore non-sexist alternatives for a more fully human social order.

The women's studies program has several major goals: to expand students' understanding of women's present status and rich history; to stimulate a critical examination of the impact of gender roles and stereotypes on social structures and individual lives; to evaluate proposals for alternative arrangements; and to connect issues addressed in the classroom with those raised in personal, political, and cultural contexts. The program challenges students to think beyond the boundaries of traditional gender roles, traditional disciplines, and established institutions. In the best tradition of a liberal arts education, women's studies encourages women and men to think critically and constructively, to redesign knowledge, and to gain a better understanding of themselves and their world.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hist 326</td>
<td>Social Class in American History (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US 125</td>
<td>American Ethnic Groups (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>US 371 / 372</td>
<td>Special Topics (1-8)</td>
<td></td>
<td>A seminar on a topic of special interest in urban studies. Prerequisite: consent of the program director.</td>
</tr>
</tbody>
</table>
The minor in women's studies consists of a minimum of 18 credit hours. Students pursuing the minor are required to take the introductory course (WS 101) and one upper-level course from among those concerned with the theory and practice of women's studies. The remaining courses must include at least one course in the arts and humanities and one course in the natural and social sciences. Students arrange their program in consultation with the program director, Professor Robin Dillon, Department of Philosophy.

**Required courses (6 credit hours)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>WS 101</td>
<td>Introduction to Women's Studies (4)</td>
</tr>
<tr>
<td>And one of the following</td>
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</tr>
<tr>
<td>WS 271</td>
<td>Independent Reading and Research (1-4)</td>
</tr>
<tr>
<td>WS 330</td>
<td>Internship in Women's Studies (3)</td>
</tr>
<tr>
<td>WS 350</td>
<td>Senior Seminar (3)</td>
</tr>
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</table>

**Elective Courses (12 credit hours)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>WS 8 / Rel 8</td>
<td>Prehistoric Religion, Art and Technology (4)</td>
</tr>
<tr>
<td>WS 41 / SR 41</td>
<td>Human Sexuality (3)</td>
</tr>
<tr>
<td>WS 42 / SR 42</td>
<td>Sexual Minorities (3)</td>
</tr>
<tr>
<td>WS 121 / Art 121</td>
<td>Women in Art (3)</td>
</tr>
<tr>
<td>WS 123 / Anth 123</td>
<td>Cultural Construction of Gender (3)</td>
</tr>
<tr>
<td>WS 124 / Hist 124</td>
<td>Women in America (4)</td>
</tr>
<tr>
<td>WS 130 / Eco 130</td>
<td>Economics of Race and Gender (2)</td>
</tr>
<tr>
<td>WS 138 / Rel 138</td>
<td>Women in Jewish History (4)</td>
</tr>
<tr>
<td>WS 152 / Clss 152 / Hist 152</td>
<td>Women in Antiquity (4)</td>
</tr>
<tr>
<td>WS 153 / Hist 153</td>
<td>Women in European History, 1500-Present (4)</td>
</tr>
<tr>
<td>WS 158 / Rel 158</td>
<td>Sex and Gender in Judaism: The Feminist Critique (4)</td>
</tr>
<tr>
<td>WS 179 / Pol 179</td>
<td>Politics of Women (4)</td>
</tr>
<tr>
<td>WS 184 / Rel 184</td>
<td>Religion, Gender, and Power (4)</td>
</tr>
<tr>
<td>WS 226 / Phil 226</td>
<td>Feminism and Philosophy (4)</td>
</tr>
<tr>
<td>WS 239 / Pol 239</td>
<td>Women and Development (4)</td>
</tr>
<tr>
<td>WS 310 / SSP 310 / AAS 310</td>
<td>Gender, Race and Sexuality: The Social Construction and Differences (3)</td>
</tr>
<tr>
<td>WS 311 / Eng 311</td>
<td>Literature of Women (3-4)</td>
</tr>
<tr>
<td>WS 318 / Psych 318</td>
<td>Seminar in Gender, Psychology, and Education (3)</td>
</tr>
<tr>
<td>WS 325 / Hist 325 / SSP 325</td>
<td>History of Sexuality and the Family (in the U.S.) (4)</td>
</tr>
<tr>
<td>WS 327 / LFren 327</td>
<td>Women Writing in French (4)</td>
</tr>
<tr>
<td>WS 341 / Soc 341</td>
<td>Women and Health (3)</td>
</tr>
<tr>
<td>WS 351 / Soc 351</td>
<td>Gender and Social Change (3)</td>
</tr>
<tr>
<td>WS 364 / Soc 364</td>
<td>Sociology of the Family (3)</td>
</tr>
<tr>
<td>WS 394 / SSP 394 / AAS 394</td>
<td>Historical Sociology (3)</td>
</tr>
<tr>
<td>WS 91, 91, 272</td>
<td>Special Topics (1-4)</td>
</tr>
<tr>
<td>291, 371, 381, 382, 391, 392</td>
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</table>

In addition, new courses may be offered annually. Students should check with the director for an updated list.

**Undergraduate Courses in Women's Studies**

**Description of Required Courses (6 credit hours)**

**WS 101. Introduction to Women's Studies (4)**

Placing women's experience at the center of analysis, the course introduces students to the key concepts, theoretical frameworks, and interdisciplinary research in the new scholarship on women. Examines how gender interacts with race, age, and class to shape human consciousness and determine the social organization of human society. (HU)

**WS 271. Independent Reading and Research (1-4)**

Independent study of selected topics designated and executed in close collaboration with member of women's studies faculty. Students taking this course as a requirement for the minor must elect the three-credit option. Prerequisite: consent of program director. (SS/HU)

**WS 330. Internship in Women's Studies (3)**

Supervised work in women's organizations or settings, combined with an analysis, in the form of a major paper, of the experience using the critical perspectives gained in women's studies courses. Placements arranged to suit individual interests and career goals; can include social service agencies, women's advocacy groups, political organizations, etc. May be repeated for credit. Prerequisites: WS 101 and consent of program director. (SS)

**WS 350. Senior Seminar (3)**

An upper-level seminar that challenges students to systematize insights gained from introductory and elective courses by applying the interdisciplinary methodology of women's studies to a focused topic. Subject matter varies semester to semester. Offered by women's studies faculty on a rotating basis. May be repeated for elective credit. Prerequisite: WS 101, or consent of program director. (SS)

**Undergraduate Elective Courses in Women's Studies**

**Description of Elective Courses (12 credit hours)**

**WS 8. (Rel 8) Prehistoric Religion, Art and Technology (4)**

Origins and early development of religions, with focus on interactions of religion, art, and technology in the Paleolithic and Neolithic periods. Special attention to the emergence of patriarchal social forms and the figure of the goddess. Interdisciplinary methods with a consideration of feminist theories of cultural development. Girardot. (HU)

**WS 41. (SR 41) Human Sexuality (3)**

Sexuality and gender roles across the life cycle, including human reproduction, decision-making, and the societal regulation of sexual behavior. (ND)

**WS 42. (SR 42) Sexual Minorities (3)**

How minority sexual identities have been the subject of speculation, misunderstanding, and sometimes violent attempts at correction or elimination. Sexual orientation, gender role, including transvestism and "drag", transsexualism, sexism, heterosexism, and homophobia. Emphasis on critical thinking, guest speakers, and discussions. (SS)

**WS 121. (Art 121) Women in Art (3)**

Women artists from Renaissance to present. Attitudes toward women artists and their work; changing role of women in art world. Visits to museums and artists' studios. May be repeated for credit, as topic varies. Gans. (HU)

**WS 123. (Anth 123) Cultural Construction of Gender (3)**

Comparative study of the meanings and social roles associated with gender. Psychological, symbolic, and cultural approaches. Tannenbaum. (SS)

**WS 124. (Hist 124) Women in America (4)**

Roles of women in American society from colonial to present times; attitudes toward women, female sexuality, women's work, and feminism. Cooper, Soderlund. (SS)

**WS 130. (Eco 130) Economics of Race and Gender (2)**

The question of the role of race and gender in economic decision-making is explored. Various sorts of discrimination are discussed in an economic framework and possible remedies are evaluated. The historical role of race and gender in the economy is also discussed. Prerequisite: Eco 1. Department permission required. (SS)

**WS 138. (Rel 138) Women in Jewish History (4)**

Contributions of, and limitations on, women at different stages of Jewish history; using both primary sources and secondary material.
WS 318. (Psych 318) Seminar in Gender and Psychology (4)
Gender as shaped by psychological and social psychological processes. Socialization, communication and power, gender stereotypes, methodological issues in sex differences research. Prerequisite: Psych 210 completed or concurrent or permission of instructor. Hyland. (SS)

WS 325. (Hist 325, SSP 325) History of Sexuality and the Family in the U.S. (3-4)
Changing conceptions of sexuality and the role of women, men, and children in the family and society from the colonial to the post-World War II era. Emphasis on the significance of socioeconomic class and cultural background. Topics include family structure, birth control, legal constraints, marriage, divorce, and prostitution. Soderlund. (SS)

WS 327. (Fren 327) Women Writing in French (4)
Reading and discussion of works written by women in French. The emphasis is on 19th and 20th Century writers, such as G. Sand, Colette, S. de Beauvoir, M. Duras, Andre Chedid. Chabut. (HU)

WS 341. (SSP 341) Women and Health (3)
Relationships of women to the medical system. Influence of medicine on women's lives and the impact of the women's movement on health care. Prerequisite: Any one of Anth 1, Anth 11, Anth 12, SSP 5, or SSP 21, or department permission. Lasker. (SS)

WS 351. (SSP 351) Gender and Social Change (3)
Changes in gender roles from social psychological and structural perspectives. Comparative analyses of men and women (including people of color) in the social structure; their attitudes and orientations toward work, family, education, and politics. Prerequisite: Any one of Anth 1, Anth 11, Anth 12, SSP 5, or SSP 21, or department permission. Spade. (SS)

WS 364. (SSP 364) Sociology of the Family (3)
Sociological analysis of families in the United States, including investigations of historical and contemporary patterns. Issues addressed include parenting, combining work and family, divorce and remarriage, family policies. Anth 363 recommended in conjunction with this course. Prerequisite: Any one of Anth 1, Anth 11, Anth 12, SSP 5, or SSP 21, or department permission. Spade. (SS)

Some scholars believe that “historians and sociologists don’t speak the same language.” However, contemporary social questions about cohabitation, marriage, the family, national politics, race and gender relations, immigration and schooling in the U.S. cannot be answered fully without the benefit of historical analysis. This seminar in applied social research will provide advanced students with both the quantitative and qualitative skills to investigate various topics in 19th and early 20th century American social and economic structure. Washington. (SS)

WS 91, 191, 272, 291, 371, 381, 382, 391, 392. Special Topics (1-4)
Intensive study of a topic of special interest not covered in other courses. May be cross-listed with relevant offerings in major department or other programs. May be repeated for credit as topic varies. Prerequisite: consent of program director. (ND)
VI.

An Overview from Past and Present

Lehigh University is independent, nondenominational, and coeducational. Founded in 1865 as a predominantly technical four-year school, the university now has approximately 4,400 undergraduates within its three major units—the College of Arts and Sciences, the College of Business and Economics, and the College of Engineering and Applied Science—and approximately 2,000 students enrolled in graduate programs offered through the graduate schools in these colleges and in the College of Education. There are undergraduates from nearly every state and U.S. territory and more than 40 foreign nations.

The university is primarily situated on the Asa Packer Campus on the north slope of South Mountain overlooking Bethlehem, Pennsylvania. Sayre Park, the wooded refuge located toward the top of the mountain, is the setting for many living groups. The residences are reached via winding private roads. Many residential units on campus command a panoramic view of the Lehigh Valley. The Appalachians are visible to the west, with an especially good view from The Lookout on the Packer Campus. Both the tower and dining room in Iacocca Hall on the Mountaintop Campus afford panoramic views of the Lehigh Valley. The campus at its highest point is 971 feet above sea level.

A substantial portion of the upper level of Lehigh's campus is maintained as a nature preserve. The preserve supports deer, squirrels, chipmunks, raccoons, wild turkeys and other birds.

Besides the Asa Packer Campus, the university has extensive athletic fields and facilities on the Murray H. Goodman Campus, two miles to the south in Saucon Valley. The university acquired the Mountaintop Campus at the end of 1986. It links the Asa Packer and Murray H. Goodman campuses and brings total land holdings in Bethlehem to 1,600 acres, nearly double the former total.

The board of trustees and university officers have established and enforce policies designed to preserve Lehigh's natural beauty. It is their contention that the environment in which the young adult university student pursues knowledge can make the total educational experience more meaningful, and that the ideal environment is separate and unique from the distractions of the nonacademic community.

There are approximately 400 members of the faculty, teaching a total of more than 2,000 course titles (not all of which are offered every semester). Among faculty members who are tenured and to whom the university has a permanent commitment, nearly all hold the doctorate degree (typically Ph.D. or Sc.D.).

In total, there are more than 2,000 employees of the university, making it the second-largest employer in the community.

History and Purpose

The principal author of the brief history of Lehigh University that follows, Dr. W. Ross Yates, holds the bachelor of arts and master of arts degrees from the University of Oregon, in his native state. He received the doctor of philosophy degree from Yale University and studied in France on a Fulbright Scholarship. He joined the Lehigh staff in 1955 and served as dean of the College of Arts and Science from 1963 to 1972. Today he is professor emeritus of government, and lives in Oregon.

When the sound of the last cannon of the Civil War died away, statesmen, educators, and industrial pioneers marshalled the victorious forces of the North and turned their attention to education. They wanted to increase the number of trained scientists, engineers, and other skilled people so they could transform the vast natural resources of the country into a strong and independent national economy.

Asa Packer was one of the industrial pioneers. He built the Lehigh Valley Railroad and controlled a coal-mining empire in the mountains of eastern Pennsylvania. He knew, as did many others, that a strong national economy depended on more than technical skills. It needed above all people broadly educated in the liberal arts and sciences—people who could combine practical skills with informed judgments and strong moral self-discipline. He kept this in mind when founding and endowing Lehigh University.

The site that Packer chose for his university was a railroad junction across the Lehigh River from Bethlehem, a community founded in 1741 by Moravian missionaries. William Bacon Stevens, Episcopal bishop of the Diocese of Pennsylvania and the first president of the university's board of trustees, in 1869 described the origin of the university as follows:

"In the fall of 1864 an interview was requested of me by the Hon. Asa Packer, of Mauch Chunk (now Jim Thorpe), Pa. He came to my house in Philadelphia, and said that he had long contemplated doing something for the benefit of his State, and especially of the Lehigh Valley. From that valley he said he had derived much of the wealth which GOD had given to him, and to the best interests of that valley he wished to devote a portion of it in the founding of some educational institution, for the intellectual and moral improvement of the young men of that region.

"After conversing with him a little while, and drawing out his large and liberal views, I asked him how much money he purposed to set aside for this institution, when he quietly answered that he designed to give $500,000. At the time of this interview no one in this country, it is believed, had offered in a single sum such an endowment for a literary institution. It was the noblest offering which an American had ever laid on the altar of learning, and more than equaled many royal donations which have carried down the names of kings as patrons of European universities.

"Filled with profound emotions at the mention of such a gift for such an object, I asked the noble donor what specific plans he had dreamed in his own mind in reference to it. His reply was, 'I am not much acquainted with these matters, but you are, and I want you if you will to devise a plan which I can put into effective operation.' I told him that I would make the attempt. I did so. I drew up the outline sketch of such an institution as I thought would give the largest results for the means used, and submitted it in a few weeks to his inspection.

"He examined it with the practical judgment and business habits with which he deals with all great questions, and adopted the scheme as the basis of his future university.

"The first meeting of the Board of Trustees, selected by Judge Packer, met at the "Sun Hotel," in Bethlehem, July 27th, 1865, and began to organize the work before them."

The trustees followed several principles in setting up the university. One was that of combining scientific and classical education. They considered both to be practical. The principle carried forward an ideal of the great 17th-Century Moravian educator, John Amos Comenius. A motto taken from the works
of Francis Bacon was used to summarize this principle, namely, Homo ministru et interpreter naturae—man, the servant and interpreter of nature, to use a free translation. That motto lives on at Lehigh, being an element in the university seal.

The trustees chose as first president a man whose education and habits expressed this principle, Henry Coppee. They established five schools, including a school of general literature in addition to four scientific schools of, respectively, civil engineering, mechanical engineering, mining and metallurgy, and analytical chemistry.

Another principle upon which the trustees insisted was that of keeping the size of the student body proportionate to the abilities of the faculty to teach them well. The university would admit only as many freshmen each year as it could be assured of providing with the highest quality of education. In the 19th century the total enrollment never exceeded several hundred students; the size has increased significantly in recent decades, along with the number of faculty members.

The trustees also insisted that Lehigh was to be nondenominational and would have an admission policy based on merit. Competitive examinations were held for applicants for admission. From 1871 to 1891 no tuition was charged, but the national financial crisis at the turn of the century decimated the value of the Lehigh Valley Railroad stock that Packer had given to Lehigh, which was the principal source of income.

At first the student body was entirely male. The contemporary ideological climate would permit nothing else. But around 1916, women were admitted to graduate programs. In 1917, the university opened its undergraduate program to them as well. Today men and women applicants are considered on an equal basis.

From the first, the students were serious-minded. In 1924, Catherine Drinker Bowen, daughter of president Drinker and a famous biographer, published a brief History of Lehigh University, in which she commented:

"Ask any college professor which brand of boy he would prefer to teach, the cigarette brand or the flannel shirt variety. Right here we offer ten to one the flannel shirts...Lehigh still holds to the emblem of the flannel shirt—long may it wave! Engineers come to college to work. A writer in the Syracuse Post in 1895 spoke truthfully when he said, 'From the first, Lehigh's characteristic has been her earnestness. It is the boast of her graduates, the inspiration of her students. Men go there to learn to take a useful part in the economy of life.'"

The university community was constantly infused with new faculty and students determined to renew and rework the original principles in the light of changing times. The students' ambition and zeal bore fruit; as alumni they carried the university's educational goals into the work of nation-building. And, having received, they gave to perpetuate Lehigh's work of service.

Today, Lehigh University still adheres to Asa Packer's goal of a liberal and scientific education for practical service. Faculty and students work to maintain high quality in instructional programs. Generous support from individuals, foundations, industry, and government help Lehigh to retain high quality of education and faculty while keeping tuition as low as possible. (Tuition covers only a part of the cost of a Lehigh education.)

**Presidents of the University**

The presidents of Lehigh University are described and their achievements cited in the following paragraphs. The years in parentheses are those served in the presidency.

**Henry Coppee** (1866-1875). Coppee served as a railroad engineer in Georgia, a captain in the Army during the Mexican War, and taught at West Point and at the University of Pennsylvania before becoming first president in 1866. Much building was done on the new university campus. A Moravian church on Packer Avenue was remodeled into Christmas Hall; a house for the president was erected on campus; and Packer Hall, the university center, was built. Coppee lectured in history, logic, rhetoric, political economy, and Shakespeare.

**John McDowell Leavitt** (1875-1880). Leavitt was an Episcopal clergyman who graduated from Jefferson College and taught at Kenyon College and Ohio University. During his incumbency, the university was divided into two schools, General Literature and Technology. As of 1876, a student could receive two engineering degrees by taking a longer course, and beginning in 1877 the master of arts, doctor of philosophy, and doctor of science degrees were established.

Linderman Library rotunda was completed in 1877. Asa Packer died in May, 1879, and Founder's Day was held in his honor the following October.

**Robert Alexander Lambertson** (1880-1893). Lambertson, a graduate of Dickinson College, practiced law in Harrisburg, Pa., and was a university trustee when asked to become president. During his administration, students and the community witnessed the first Mustard and Cheese dramatic presentation. A gymnasium (now Coppee Hall) was erected, and Chandler Chemistry Laboratory was built, now known as Chandler-Ullman Hall. Lehigh was also building its reputation for academic excellence; the mechanical engineering department was established in 1881 and the Lehigh chapter of Phi Beta Kappa was founded in 1887.

**Thomas Messinger Drown** (1895-1904). Drown studied medicine at the University of Pennsylvania and went abroad to study chemistry. Thereafter he was professor of chemistry at Lafayette College. In 1895 he assumed the presidency of Lehigh and was greatly interested in furthering the university's development as a technical school.

His first years were difficult ones because the Panic of 1893 decimated the university's stock holdings in the Lehigh Valley Railroad. Nevertheless, Lehigh managed to grow in enrollment, academics, and in physical plant. Williams Hall was completed. The curriculum leading to a degree in arts and engineering was established, as was the department of zoology and biology. New curricula were adopted in metallurgical engineering, geology, and physics.


**Henry Sturgis Drinker** (1905-1920). Drinker, an 1871 Lehigh graduate, was the only university alumnus ever to become president. In 1907, the alumni endowment fund began, the Lehigh Alumni Bulletin was first published in 1913, and the Alumni Association was incorporated in 1917.

Drinker, besides being a lawyer, was a mechanical engineer and had been largely instrumental in solving the problems of constructing the two-mile-long Musconetcong Tunnel, an engineering feat that made possible a railroad line between Easton, Pa., and New York City. He started a tradition of businesslike management of university affairs.

During Drinker's years, more buildings were completed: the original section of Fritz Engineering Laboratory, Drown Hall, Coxe Mining Laboratory, Taylor Hall, Taylor Gymnasium and Field House, Taylor Stadium and Lambertson Hall. Drinker's interest in horticulture led to the planting of many rare trees and plants.

A teacher's course and business administration course were begun in 1909 and in 1918 the university was divided into three colleges, liberal arts, business administration, and engineering—the roots of colleges of today. Army ROTC was established in 1919.

Drinker's daughter, Catherine Drinker Bowen, went on to become a historical writer of note. Her experiences as the
daughter of a Lehigh president and occupant of the President's House are recorded in Family Portrait (Atlantic Little-Brown).

Drinker resigned in 1920 and Natt M. Emery, vice president, served as chief executive officer until 1922.

Charles Russ Richards (1922-1935). Richards took office in 1922. During his presidency, the first graduate degrees were awarded to women. Lehigh faced a shortage of students from 1929 to 1936 as a result of the Depression, but the newly established office of admission, as well as university scholarships, fellowships, and deferred tuition payments, helped to ease the shortage.

Changing concepts of education were evident in several newly organized academic offerings: philosophy, music, psychology, journalism, history, and fine arts. The majors system was instituted as were the senior comprehensive examinations in the Arts College. The placement bureau, a public relations office, and a student health service were organized.

The Alumni Memorial Building—a memorial to the Lehigh alumni who served in World War I—and Packard Laboratory both were completed in 1925. In the same decade, a major addition to Linderman Library also was completed.

Clement C. Williams (1935-1944). Williams, a civil engineer, was president during an era of unprecedented alumni support. Undergraduate enrollment rose to an all-time high, passing 2,000 in 1938. Richards and Drinker residential houses, and the Ullmann wing adjoining the Chandler Chemistry Laboratory, were built. Grace Hall, the first arena-type facility of any size on campus, was completed in 1940, the gift of Eugene G. Grace, an 1899 graduate, who headed the board of trustees. A Graduate School implemented the programs in the three colleges. Williams retired in 1944, and the university was without a president for approximately two years.

Martin Dewey Whitaker (1946-1960). Dr. Whitaker, who had been director of the Atomic Energy Commission Laboratory at Oak Ridge, Tenn., and had worked in developing the atomic bomb, faced the responsibility of helping the university community readjust to peacetime conditions after World War II. During his time as president, Lehigh's assets nearly tripled; the endowment more than doubled to $18 million. Many buildings were renovated, and the Dravo House and McClintic-Marshall House residence halls were built. The faculty increased in number by 75 percent and the first endowed distinguished professorships were established.

The Centennial development program was begun in 1959. It raised more than $22 million for faculty salaries and construction that later included Whitaker Laboratory.

An extensive renovation and enlargement project associated with Packer Hall was undertaken in 1957, and, upon completion in 1958, the building became a university center.

Whitaker died in office.

Harvey A. Neville (1961-1964). Dr. Neville was the only faculty member ever elected president. His association with the university began in 1927 as an assistant professor of chemistry. During his three-year term as president, the first phase of the Saucon Valley athletic complex was completed, and Sayre Field was opened atop South Mountain. The Center for Information and Computing Science was established.

Neville, a strong supporter of research who fostered its growth on the campus, died in 1983.

Deming Lewis (1964-1982). Willard Deming Lewis became Lehigh's 10th president after a distinguished career as a space engineer and research administrator.

Dr. Lewis earned three degrees at Harvard and two from England's Oxford University, where he was a Rhodes Scholar in advanced mathematics. In 1941, he joined Bell Telephone Laboratories, and in 1962 he became general manager of systems development with Bellcomm Inc., which engineered systems for the Apollo project that placed the first man on the moon.

Lewis, who died in 1989, received 33 U.S. patents on such devices as microwave antennas and filter and digital error detection systems. He helped write the equations describing a stylus sliding through a warped groove.

During Lewis's tenure as Lehigh president, women were admitted as undergraduate students in 1971. New majors were begun in natural science, biology, social relations, geological sciences, environmental science and resource management, religion studies, computer engineering, computing and information science, applied mathematics, management science, American studies and other fields. Six research centers and seven institutes were established.

Capital campaigns brought in more than $130 million, and construction was completed on Maginnes Hall, Whittaker Lab, Mart Science and Engineering Library, Sinclair Lab, the Seeley G. Mudd Building, Neville Hall, Rathbone Hall dining room, 13 fraternity houses, the Centennial I and Centennial II residential complexes, the Brodhead House residence hall, the Trembley Park student apartments, the Saucon Village Apartments, the Philip Rauch Field House and the Stabler Athletic and Convocation Center. The restoration of Packer Memorial Church was completed, and Packard Lab was renovated.

The original Physics Laboratory is now named in Lewis's honor, as is the indoor tennis center.

Peter Likins (1982-1997). Dr. Likins, who earned a B.S. and Ph.D. from Stanford, and an M.S. from the Massachusetts Institute of Technology, became Lehigh's 11th president in 1982. He sought balanced excellence in undergraduate programs while pursuing focused objectives in graduate study and research.

Under Likins, Lehigh doubled in size with the purchase in 1986 of 742 acres of land and a research complex from Bethlehem Steel Corp. The new Mountaintop Campus links the Asa Packer and Goodman campuses.

Lehigh also added many new buildings and facilities. Perhaps most notable was the $33-million Zoellner Arts Center, which provided a new home to Lehigh's departments of music and theatre and to the University Art Galleries, and made Lehigh a center for the fine arts. The Arts Center and the new Rauch Business Center, home of the College of Business and Economics, were built on the site of Taylor Stadium, which was replaced by Goodman Stadium on Lehigh's athletic campus.

Also during Likins' term, Lehigh built a $20-million, state-of-the-art telecommunications system, the E.W. Fairchild-Martindale Library and Computing Center -- one of the most automated libraries anywhere -- and the Harold S. Mohler Lab, which honor the former chairman of the board of trustees.

Also dedicated was the Sherman Fairchild Center for the Physical Sciences, which includes the renovated Physics Building (renamed Lewis Lab), and the adjoining Sherman Fairchild Lab.

Lehigh became home to the North East Tier Ben Franklin Advanced Technology Center, which has helped hundreds of new high-technology businesses get started. And the university led the way in establishing the Colonial League, now the Patriot League, in football. The league is committed to the Lehigh tradition of "scholar-athletes."

Financial support grew from $10 million a year to over $24 million. With over half of alumni making gifts, Lehigh ranked among the top Ph.D.-granting schools in percentage of alumni donors.

Likins' term also saw the establishment of the Lehigh Valley Center for Jewish Studies at Lehigh, the Center for Advanced Technology for Large Structural Systems, largest of its kind in North America, and centers in integrated circuits, management studies, chemical process modeling and control, and international studies.
William C. Hittinger (1997-98). A former chairman of the university’s board of trustees, Hittinger became interim president after the departure of Peter Likins. A member of the National Academy of Engineering, Hittinger served for 22 years on the board of trustees. He graduated from Lehigh in 1944 with a B.S. in metallurgical engineering, and received an honorary Doctor of Engineering degree from Lehigh in 1973. During a 40-year career in the electronics industry, Hittinger worked for Western Electric Co., National Union Radio Corp., Bell Telephone Laboratories, Bellcomm Inc., General Instrument Corp., and RCA Corp. At Bellcomm, he oversaw systems engineering for NASA’s manned spaceflight program, and at RCA, where he became executive vice president, he was responsible for corporate technology, patents, licensing, international business and marketing development, and corporate technology planning.

Hittinger was a member of President Reagan’s National Security Telecommunications Advisory Committee from 1982-86. He was also a member of the U.S.-Brazil Presidential Committee on Science and Technology and a member of the board of directors for eight companies.

Hittinger served as national president of the Lehigh Alumni Association 1971-72 and received the prestigious L-In-Life award in 1979. An ROTC student at Lehigh, Hittinger served in the U.S. Army in 1943-46 during World War II, rising to the rank of captain.

During Hittinger’s term as chairman of the board of trustees, Lehigh began construction of the Zoellner Arts Center, completed the Ulrich Student Center, aggressively improved its financial aid for undergraduates, and completed the $300 million Campaign for Preserving The Vision. As president, Hittinger realigned the Iacocca Institute into the College of Business and Economics, oversaw the construction of the new Sayre Park Village residential complex, and helped Lehigh move forward during a time of presidential transition.

Gregory C. Farrington (1998-). Dr. Farrington was appointed Lehigh’s 12th president in May 1998. He had been dean since 1990 of the School of Engineering and Applied Science at the University of Pennsylvania, where he was responsible for the academic and financial oversight of the school.

Farrington, who earned a B.S. from Clarkson University, and an A.M. and Ph.D. from Harvard, all in chemistry, specializes in solid state electrochemistry. He holds or shares more than two dozen patents and has written or edited books, book chapters and 100 technical papers. Before joining Penn, he was a research chemist for General Electric Co.’s Corporate Research and Development Center in New York state.

At Penn, Farrington established new graduate and undergraduate interdisciplinary degree programs. At Lehigh, he has called on faculty, students, staff and alumni to build a university that rivals the best in America. He will strive to create new interdisciplinary programs and to promote innovative teaching methods that take advantage of new technologies where appropriate while preserving the best of established traditions. He has taken steps to improve relations with Lehigh’s neighbors in the City of Bethlehem, and to reduce harmful use of alcohol by students. And he has realigned Lehigh’s management structure in an effort to improve service and efficiency and also to strengthen Lehigh’s research programs.

Farrington’s goals received a significant boost when Peter C. Rossin, a member of Lehigh’s Class of 1948, established a $25-million endowment for the engineering college, which was subsequently dedicated as the P.C. Rossin College of Engineering and Applied Science. Rossin’s gift is the largest Lehigh has ever received.

Farrington serves on the boards of St. Luke’s Hospital in Bethlehem, the Lehigh Valley Economic Development Corp., the Mellon Foundation, Clarkson University and the Wharton-SEI Center for Advanced Studies in Management. He chairs the Materials Research Society Young Investigator Award Committee, and has served as Councillor of the society, chair of the Physical Electrochemistry Committee of The Electrochemical Society, president of the International Society for Solid State Ionics, and editorial board member of Chemistry of Materials, Solid State Ionics and MultiVersity.

A native of Bronxville, N.Y., Farrington received an honorary degree from the University of Uppsala in Sweden in 1984 and the prestigious Cannizzaro Gold Medal of the Italian Chemical Society in 1998.

University Campuses

Lehigh University’s three campuses are located in Bethlehem, Pa., and comprise 1,600 acres.

Asa Packer Campus. Lehigh’s main academic campus, encompassing approximately 360 acres on the north slope of South Mountain overlooking Bethlehem, is a wooded area where most students attend class and live. This contains the original campus of the university.

Murray H. Goodman Campus. During the 1960s, the university acquired extensive acreage in the Saucon Valley just south of South Mountain. Development of one of the nation’s finest collegiate athletic complexes has continued since that time. The 500-acre campus now includes the Murray H. Goodman Stadium and other athletic fields, as well as the 6,000-seat Stabler Athletic and Convocation Center, the North East Tier Ben Franklin Advanced Technology Center, the Philip Rauch Field House, the Varsity House locker facility, and the Lewis Indoor Tennis Facility. The campus is named for a major benefactor, Lehigh alumnus Murray H. Goodman, of West Palm Beach, Fla.

Mountaintop Campus. Lehigh bought this campus from Bethlehem Steel Corp. in 1986. It contains 670 acres of woods and a 72-acre research site with 8 buildings, five of which are owned by the University, including a landmark tower building visible for miles around. Acquisition of the facilities—the largest single transaction in Lehigh history—connects the two older campuses. The Mountaintop Campus houses the College of Education; the departments of Biological Sciences and Chemical Engineering; programs in biochemistry, biotechnology, ATLSS (Advanced Technology for Large Structural Systems) center, Energy Research Center, and Ben Franklin incubator companies.

University Buildings

Lehigh has a major collection of 19th-century buildings designed by such prominent architects as Addison Hutton (1834-1916), Edward T. Potter (1831-1904) and the firm of Furness and Evans (Frank Furness, 1839-1912).

The university’s newer structures include the Goodman Stadium (1988), the Sherman Fairchild Center for Physical Sciences (1976, 1986), the E. W. Fairchild-Martindale Library and Computing Center (1985), the Stabler Athletic and Convocation Center (1979), the Brodhead House residential facility (1979), the Seeley G. Mudd Building and Neville Hall in the chemistry complex (1975), the Philip Rauch Field House (1975), the Rauch Business Center (1990), the Lewis Tennis Center (1994), and the new Ulrich Student Center in Grace Hall.

Recently completed just east of the Rauch Business Center is the new Zoellner Arts Center, which houses a 1,000-seat music auditorium, a 300-seat theatre, a permanent art gallery and museum store, and the departments of music and theatre. A 350-car parking garage is on the same site.
Opened in 1998 in Sayre Park is a new residential complex of three apartment buildings and a community building. This facility is used for upperclass student housing.

Altogether, the three campuses contain 147 buildings with more than 3.5 million square feet of floor space.

In the following list, the first date after the name of each building indicates the year of construction. The second date indicates the year of a major addition.

**Campus Landmarks**

**Alumni Memorial Building** (1925). This edifice of Gothic design, housing the Visitor Center, Admissions and other administrative offices and those of the Alumni Association, represents a memorial to the 1,921 Lehigh alumni who served in World War I and the 46 who died. The building was designed by Theodore G. Visscher, Class of 1899, and James Lindsey Burley, Class of 1894.

**E. W. Fairchild-Martindale Library and Computing Center** (1985). The high-technology building houses science and engineering holdings and a computer center. Construction was made possible by a major gift from Harry T. Martindale, a 1927 Lehigh graduate, and his wife, Elizabeth, daughter of the late Edmund W. Fairchild, founder of a business-publications and communications empire.

**Linderman Library** (1877). The rotunda, designed by Addison Hutton, was built as a gift to the university by founder Asa Packer as a memorial to his daughter, Lucy Packer Linderman. The rotunda is surrounded except on the south by a major addition constructed in 1929. The building houses more than 20,000 rare books and volumes related to the humanities and social science. The Bayer Galleria of Rare Books, made possible by a gift from Curtis F. Bayer, '35, was dedicated in 1985.

**Packer Memorial Church** (1887). The church was the gift of Mary Packer Cummings in memory of her father, founder Asa Packer. It was dedicated on Founder’s Day, October 13, 1887. The building was designed by Addison Hutton; the stained-glass window over the main door is attributed to Louis Comfort Tiffany.

**President’s House** (1868). This 21-room residence, designed by Edward Potter, is the home of university presidents and is often used for receptions on special university occasions.

**Packer Hall, The University Center** (1868). When construction of the building began in 1865, a railroad was built to transport stone to the site. The building, designed originally by Potter, was extensively renovated and enlarged in 1958.

The building was constructed at the expense of the founder, who vetoed a plan to erect it of brick. “It will be built of stone,” Asa Packer responded.

Today the building houses student and faculty dining facilities, a food court, deans’ offices, the journalism and communications department, the Women’s Networking Center, the student radio station (WLVR), a bank office, and conference facilities.

**Academic and Research Facilities**

**Chandler-Ullmann Hall** (1883, 1938, respectively). These adjoining buildings formerly were the William H. Chandler Chemistry Building (designed by Hutton) and the Harry M. Ullmann Chemistry Laboratory. Chandler served as acting university president, 1904 and 1905, and taught chemistry from 1871 to 1906. Ullmann served as chairman of the chemistry department. The building has been named a National Historic Chemical Landmark by the American Chemical Society.

The Department of Art and Architecture, division of urban studies, and Department of Psychology are located in Chandler-Ullmann.

**Christmas-Saucon Hall** (1865 and 1872, respectively). Christmas Hall is the university’s oldest building. When Asa Packer acquired the South Mountain site for the university in 1865, a Moravian church was being constructed. The newly formed university took over the building and completed it for use in recitations and as a dormitory and chapel. The name Christmas Hall was chosen in keeping with Moravian religious tradition. In 1872, Saucon Hall was constructed a few feet to the east of Christmas Hall. The buildings were connected with the construction of a “hyphen” in 1926. The building houses the Department of Mathematics and classrooms.

**Coxe Hall** (1883). The building originally housed classrooms and a gymnasium. It is named in honor of Henry Coppee, first president. The building is used for classes and offices while awaiting renovations for the department of journalism.

**Coxe Laboratory** (1910). Originally a mining laboratory, the structure is named for Eckley B. Coxey, pioneer mining engineer and trustee of the university. The building is now the headquarters of the military science ROTC program.

**Drown Hall** (1908). The building, designed by Furness and Evans, is a memorial to Thomas M. Drown, president from 1895 to 1904. It is headquarters for the English Department and the Center for Writing, Math & Study Skills.

**Fritz Engineering Laboratory** (1909, 1955). The laboratory is named for John Fritz, pioneer in the steel industry in the United States and a member of the university’s original board of trustees. Fritz provided funds for the original section; a seventy-addition accommodates the university’s testing machine, which is capable of applying a five-million-pound load to tension or compression members up to forty feet in length. The hydraulic testing machine is the largest facility of its kind currently in operation in the world. The laboratory is used primarily by the Department of Civil and Environmental Engineering.

**Jacobs Hall**. Known as the tower building, it houses the College of Education, the chemical engineering department, the biological sciences department, as well as a dining room and food service facilities, plus a teleconferencing classroom.

**Imbt Laboratories**. This is primarily a high-bay research lab space where the ATLSS project was constructed, and where chemical engineering and Energy Research Center have major research facilities. It is also the headquarters of the “Fleet of the Future” program and the Energy Research Center.

**Johnson Hall** (1955). The building houses the university health service, the counseling service, the chaplain’s office, campus police, and the parking services office, as well as the Office of Continuing, Distance and Summer Studies. Earle F. “Coxey” Johnson, ’07, a director of General Motors Corp. and university trustee, provided funding for the structure.

**Lamberton Hall** (1907). The structure served as the university commons and dining room until the renovation of Packer Hall in 1958. The building honors the memory of Robert A. Lamberton, third president. It most recently housed the music department until its move to the Zoellner Arts Center.

**Maginnis Hall** (1970). The multilevel structure is headquarters for the College of Arts and Sciences and also houses the departments of modern languages and literature, history, international relations, political science, and religion studies, as well as the Science, Technology, and Society Program, the Lehigh Valley Center for Jewish Studies, and the Center for International Studies. The university bookstore is located on the
ground floor. The building is named for Albert B. Maginnes, '21, who was a lawyer and university trustee.

Mart Science and Engineering Library (1968). This structure honors the memory of Leon T. Mart, '13, and his son, Thomas, '51. It operates in conjunction with the E. W. Fairchild-Martindale Library and Computing Center.

Seeley G. Mudd Building (1975). This seven-story building houses the chemistry department. The late Seeley G. Mudd was a California medical doctor. The Seeley G. Mudd Foundation, of Los Angeles, made a major gift toward the building.

Neville Hall (1975). This building in the chemistry complex has three auditoriums used for lectures and events. The building is named for Dr. Harvey A. Neville, president from 1961 to 1964, who was a chemist.

Newman Association Center. This Victorian structure, until the mid-1970s used as a private residence, was renovated by the Newman Association and serves as a center for students and a residence for its director, a Roman Catholic chaplain.

Packard Laboratory (1929). The structure was the gift of James Ward Packard, Class of 1884, the electrical pioneer and inventor of the Packard automobile who served as a university trustee. The first Packard automobile (1898) is displayed in the lobby. The building is the headquarters for the College of Engineering and Applied Science. It also houses classrooms and laboratories for mechanical engineering and mechanics and for electrical engineering and computer science. An auditorium accommodates large classes and various events.

Philosophy Building (1879). This small building just below Packer Memorial Church was constructed as a porter's lodge. Today it houses the philosophy department.

Price Hall. This structure formerly was a brewery named Die Alte Brauerei. In 1912 it was remodeled to serve as a dormitory, and it was named in honor of Henry Price, president of the university board of trustees. It serves as the home of the sociology and anthropology department.

Rathbone Hall (1971). This building's upper level is a major student dining facility, with window walls affording a panoramic view of the Lehigh Valley. The building bears the name of its donor, Monroe Jackson Rathbone, '21, president of the university board of trustees from 1957 to 1973. Rathbone was chairman of the board, Standard Oil Co. (New Jersey), now Exxon Corp., and was a major innovator in the oil industry. The lower level houses the Residential Services Office.

Rauch Business Center (1990). Philip Rauch '33, L.L.D. '79, retired Chairman of the Board and Director of the Parker-Hannifin Corp., made the principal contribution to build this facility. Lehigh's Rauch Business Center was dedicated in 1990 as the state-of-the-art home of the university's College of Business and Economics. The $17.8-million facility has 115,000 square feet of floor space on five stories and features a diverse array of classrooms, auditoria, and conference rooms, and is also home to the Career Services and Corporate Relations Office.

Sayre Building (1869). Originally known as the Sayre Observatory, the dome that once housed the telescope can still be seen. The Graduate Student Council is headquartered here.

Sherman Fairchild Center for the Physical Sciences (1892, 1976, 1986). The center, completed with help from the Sherman Fairchild Foundation, houses classrooms and laboratories for undergraduate and graduate students in physics, faculty offices and a 260-seat auditorium. The complex includes the Lewis Laboratory, the original five-story stone structure built in 1892, the Sherman Fairchild Laboratory for Solid-State Studies built in 1976, and the 1986 addition comprised of the Oberkotter Auditorium and research laboratories.

Sinclair Laboratory (1970). This facility houses the Zettlemoyer Center for Surface Studies, and other research laboratories. It is named for Francis MacDonald Sinclair, and was the gift of his widow, Jennie H. Sinclair.

Whitaker Laboratory (1965). This five-story structure with an adjoining two-level classroom-auditorium section honors the memory of Martin Dewey Whitaker, university president from 1946 to 1960. The building serves the Department of Materials Science and Engineering and the Materials Research Center. There are laboratories for high-pressure research and reaction kinetics, nuclear studies, analog computation, process control, high-temperature thermodynamics and kinetics, and fine structures and metallography. The Office of International Education is also located in the building.

Willbur Workshop (1908). During most of its life, the building served as a power plant with some early engineering laboratory use. Renovated during the 1970s, it provided performing space for student theatrical productions, until the Zoellner Arts Center was built, and planning is now underway to renovate it for student shops and project studios for the IPD (Integrated Product Development) program.

Williams Hall (1903). This brick structure was the gift of Edward H. Williams, Jr., Class of 1875. Dr. Williams was a professor of mining and geology. The building contains classrooms and laboratories for the departments of biological sciences and of earth and environmental sciences. A small greenhouse adjoins the building. The building was extensively renovated and a fourth story added in 1956 following a fire.

Zoellner Arts Center (1997). With major gifts from Vickie and Robert Zoellner '54, Dorothy and Dexter Baker '50, and Claire and Theodore Diamond '37, Dagit-Saylor Architects created a 105,000 sq. ft. structure designed to showcase Lehigh's rapidly growing programs in the performing and visual arts as well as the departments of music and theater and 5,000 sq. ft. of exhibition space for the Lehigh University Art Galleries. Baker Hall has a seating capacity of more than 1,000, Diamond Theatre features a thrust stage and seating for 307; and a "black box" theater provides flexible space for experimental productions.

Athletic and Convocational Facilities

Murray H. Goodman Stadium (1988). Joanie and Murray Goodman '48, L.L.D. '88, were the principal benefactors. On October 1, 1988, Lehigh opened the gates to the Murray H. Goodman Stadium, located on the Goodman Campus. Capacity is 16,000, and the stadium features a three-tiered press box, and limited chair back seating, with a picturesque South Mountain in the background.

Grace Hall (1940). The building is named for its donor, Eugene G. Grace, Class of 1899, who was chairman of Bethlehem Steel Corp. and president of the university's board of trustees, 1924 to 1956. The building's lower level seats 3,200 and is used for intramural sports, wrestling, and women's varsity volleyball as well as concerts and lectures. Grace Hall serves as the headquarters and offices for Lehigh intramural and club sports. The upper level houses the newly renovated Ulrich Student Center, including movie theatre, gameroom and mailboxes.

Lewis Tennis Facility (1994). An anonymous donor made possible the construction of four indoor tennis courts for
recreational use as well as team practice, and is named for former Lehigh President W. Deming Lewis.

**Philip Rauch Field House** (1976). Philip Rauch, '33, L.L.D. '79 made a gift toward the facility. The building has 62,000 square feet of uninterrupted floor space—the equivalent of two football fields—for a variety of athletic activities. It has a six-lane, one-eighth-mile flat track.

**Sayre Field** (1961). Located atop South Mountain, the field is used for intramural sports.

**Stabler Athletic & Convocation Center** (1979). This arena provides seating for 6,000 people for concerts, spectator sports, including Lehigh's basketball teams, and other events. University trustee Donald B. Stabler, '30, made a major financial contribution toward the facility.

**Taylor Gymnasium** (1904 and 1913). This structure was the gift of Charles L. Taylor, Class of 1876, who was a friend and business associate of steel magnate Andrew Carnegie. There are two indoor swimming pools, two basketball courts, the Welch Fitness Center, men's and women's locker rooms, two racquetball and two squash courts, a steam room, a multipurpose dance/aerobics room, and a Sports Medicine Complex. The athletic department offices are also housed in the Warren (Pete) Musser wing. The Roger Penske Hall of Fame area opened in the spring of '96.

**Varsity House** (1963). The building houses lockers for varsity teams. It is located on the Murray H. Goodman Campus.

**Central Heating/Cooling Plant**
Central Heating and Refrigeration (1969). This glass-walled building houses three boilers that can be fired by either oil or gas. Other equipment provides chilled water for air conditioning.

**Technology Center**
Ben Franklin Building (1972). Situated on the Murray H. Goodman Campus in Saucon Valley, the building houses the Lehigh-based North East Tier Ben Franklin Advanced Technology Center and the Manufacturers Resource Center.

**Residence Halls**
**Brodhead House** (1979). This structure is the university's first high-rise residential facility. The six-story building includes 4-person suites on the five upper floors, with a dining facility and lobby on the entrance level. The building is named in memory of Albert Brodhead, a member of the Class of 1888 who died in 1933, leaving 51 Bethlehem properties to his alma mater.

**Dravo House** (1948). This 5-story stone edifice is the university's largest residential facility. It bears the name of two brothers, Ralph M. Dravo, Class of 1889, and Francis F. Dravo, Class of 1887, who founded the Dravo Corp., a Pittsburgh-based international construction company. Both men served as university trustees.

**Drinker House** (1940). This stone building honors the memory of Henry S. Drinker, Class of 1871, university president from 1905 to 1920.

**McClintic-Marshall House** (1957). This U-shaped stone structure was built in memory of Howard H. McClintic and Charles D. Marshall, both Class of 1888, who founded the McClintic-Marshall Construction Co. The firm was the world’s largest independent steel fabricating firm before its acquisition by Bethlehem Steel Corp. in 1931. It built locks for the Panama Canal and constructed the Golden Gate Bridge in San Francisco Bay.

**Richards House** (1938). The building honors the memory of Charles Russ Richards, president of the university from 1922 to 1935. The building is constructed of stone in modified Gothic design.

**Sayre Park Village** (1998). This new residential complex is comprised of three apartment buildings and houses students in three- and four-person apartments. Included is a fourth multipurpose community building and outdoor recreation facilities.

**Taylor Residential College** (1907, 1984). The U-shaped building is one of the earliest concrete structures ever built. It was the gift of industrialist Andrew Carnegie in honor of his friend and associate, university trustee Charles L. Taylor, Class of 1876. The interior of the building was reconstructed and the exterior refinished prior to the facility becoming Lehigh’s first residential college in 1984.

**Trembley Park** (1975). This seven-building undergraduate apartment complex is named in memory of Francis J. Trembley, Lehigh professor and pioneer ecologist.

**Warren Square Complex**. This cluster of six residence halls is located on Warren Square and Summit Street. They are upperclass facilities and some are used as special-interest houses.

**Centennial II complex** (1970)
**Beardslee House**. Dr. Claude G. Beardslee was chaplain from 1931 to 1947.

**Carothers House**. Dr. Neil Carothers was dean of business.

**Palmer House**. Dr. Philip M. Palmer was dean of the arts.

**Stoughton House**. Dr. Bradley Stoughton was dean of the engineering college, 1936 to 1939.

**Williams House**. Dr. Clement C. Williams was president of the university, 1935 to 1944.

**Saucon Village Apartments** (1974)
The five-building garden apartment complex includes housing for married, graduate, and undergraduate students.

**Diamond**. Dr. Herbert M. Diamond, professor emeritus of economics, retired in 1964.

**Gipson**. Dr. Lawrence Henry Gipson, research professor of history, bequeathed his estate to the university to establish the Lawrence Henry Gipson Institute for Eighteenth-Century Studies. Dr. Gipson wrote a monumental 15-volume history, The British Empire before the American Revolution. He won the Pulitzer Prize for volume 10, The Triumphant Empire: Thunderclouds Gather in the West, 1763-1766.

**Hartman**. Dr. James R. Hartman was chairman of the department of mechanical engineering and mechanics.

**More**. Dr. Robert P. More, ’10, dean of the College of Arts and Sciences, who also taught German for forty years, bequeathed to the university his $746,000 estate, amassed after investing $3,000 in IBM stock. The university child care center is located in this building.
Severs. Dr. J. Burke Severs, of Bethlehem, is distinguished professor emeritus of English. He is a Chaucerian scholar.

Fraternities and Sororities

The university has a strong fraternity tradition, dating back to 1872. Since the admission of undergraduate women in 1971, several sororities have come into being. Some 700 men live in fraternities.

Most of the fraternities have houses located in Sayre Park, while two others are situated off campus. All are chapters of national fraternities.

An alphabetical listing follows. The date of the founding of the chapter is given in the first column. The second column lists the date the chapter occupied its present house; any additional date indicates the most recent addition or major renovation.

<table>
<thead>
<tr>
<th>Fraternity</th>
<th>Year of Founding</th>
<th>Year of Moving into Present House</th>
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<tr>
<td>Alpha Chi Rho</td>
<td>1918</td>
<td>1968</td>
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<td>Alpha Sigma Phi</td>
<td>1929</td>
<td>1961</td>
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<td>Alpha Tau Omega</td>
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<td>1922 1968</td>
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<td>Zeta Psi</td>
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</table>
* Active chapter without a house on Lehigh Campus.

There are eight sororities. All are nationally affiliated. Six reside in the Centennial I Complex and two, Alpha Phi and Gamma Phi Beta, reside in Sayre Park. Nearly 400 women live in sororities.

The sororities are listed with year of moving into their present house in the second column.

<table>
<thead>
<tr>
<th>Sorority</th>
<th>Year of Moving into Present House</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha Chi Omega</td>
<td>1988 1997</td>
</tr>
<tr>
<td>Alpha Gamma Delta</td>
<td>1975 1985</td>
</tr>
<tr>
<td>Alpha Omicron Pi</td>
<td>1983 1996</td>
</tr>
<tr>
<td>Alpha Phi</td>
<td>1975 1996</td>
</tr>
<tr>
<td>Delta Gamma</td>
<td>1982 1987</td>
</tr>
<tr>
<td>Gamma Phi Beta</td>
<td>1975 1998</td>
</tr>
<tr>
<td>Kappa Alpha Theta</td>
<td>1984 1986</td>
</tr>
<tr>
<td>Pi Beta Phi</td>
<td>1997 1998</td>
</tr>
</tbody>
</table>

Centennial I complex (1965)

**Condon House.** Located at the east end of the Centennial I complex. Dr. Wray H. Congdon served as dean of students, dean of the graduate school, and special assistant to the president. Alpha Chi Omega sorority is housed in Condon.

**Emery House.** It is named for Dr. Natt M. Emery, who was vice president and controller. Pi Beta Phi sorority is housed in Emery.

**Leavitt House.** The Rev. Dr. John McD. Leavitt was the second president, 1875 to 1879. Alpha Gamma Delta sorority is housed in Leavitt.

**McConn House.** C. Maxwell McConn was dean of the university from 1923 to 1938. Alpha Omicron Pi sorority is housed in McConn.

**Smiley House.** Dr. E. Kenneth Smiley served as vice president from 1945 to 1964. Kappa Alpha Theta sorority is housed in Smiley.

**Thornburg House.** Dr. Charles G. Thornburg was professor and head of the Department of Mathematics, 1895 to 1923. Delta Gamma sorority is housed in Thornburg.

Alpha Phi sorority is housed in the former Pi Lambda Phi fraternity house.

Gamma Phi Beta sorority is housed in the former Sigma Phi fraternity house.

In Bethlehem, An Educational Tradition

Lehigh University shares in the historical heritage of Bethlehem, even though, having been founded in 1865, it is a relative newcomer. The fact that Lehigh was established in Bethlehem reflects the tradition of education established by the community's first settlers thirty years before the founding of the nation.

The first Moravians were among the many German religious sects that came to the New World, and especially to Pennsylvania, during the early 1700s. But unlike William Penn, who established his sylvanias as a new land where he might hold his Quaker beliefs away from England's oppression, the Moravians came as missionaries with the intent of converting the Indians to Christianity. For this purpose they settled the Lehigh Valley.

The early Moravians were industrious. Their first building, the Gemein Haus (community house) was completed in 1741. This building stands today, one of thirty-nine remarkably preserved pre-Revolutionary War buildings constructed by the Moravian settlers and in continuous use ever since by the Moravian community. Many of these buildings are located on Church St., west of the City Center; industrial buildings are located in the 18th Century Industrial Area in the Monocacy Creek valley west of the business district.

The leader of the Moravians was Count Nicholas von Zinzendorf of Dresden. He arrived in the settlement in time for their observance of Christmas Eve in 1741 and gave the settlement the name Bethlehem—"house of bread".

The settlers built high-quality structures of stone, demonstrating principles of engineering that were not generally used elsewhere. They were interested in music, and established the first symphony orchestra in America. In 1748, the settlement had a fourteen-man orchestra. The community's first organ was used elsewhere. They were interested in music, and established the first symphony orchestra in America. In 1748, the settlement had a fourteen-man orchestra. The community's first organ was built in 1757 by John Gottlob Klemm. The musical tradition, including the trombone choir, continues today, perhaps most visibly in the Bach Choir of Bethlehem, whose yearly Bach Festival is held in the university's Packer Memorial Church. In 1985, the 300th anniversary of the birth of Johann Sebastian Bach was observed.

Zinzendorf envisioned Bethlehem as the center for manufacturing; outlying Moravian settlements, such as Nazareth, Pa. would be primarily devoted to agriculture. On October 15, 1742, a large barn was "raised" with the help of most...
of the residents. Three months later a grist mill at the community spring produced the first flour. In 1758, the Sun Inn was built along Main St., a haven for travelers. Reconstruction of the picturesque inn was completed in 1982, and it now operates as a community center and restaurant.

Zinzendorf's determination that Bethlehem would be a major industrial center was assisted by the completion in 1755 of the water works, the first public utility in the New World.

The Moravian dedication to education was an extension of the philosophy of John Amos Comenius, who had written, "Everyone ought to receive a universal education." The Moravian educational institutions that continue today, including Moravian Academy and Moravian College, stem from this tradition.

The Moravians, although avowedly opposed to war, found their community pressed into service as a hospital when Washington's troops bivouacked at Valley Forge during the winter of 1777-78. Washington came to the community once, and many other Continental Army officers were visitors.

The Sun Inn was also used as a hospital during the war; among its patients was an aristocratic renegade from France, Marie Joseph Paul Ives Gilbert Motier, the Marquis de la Fayette. Lafayette had come to assist the Continental Army aboard his own ship, the "Victory." Fifty years later a college in Easton was named in his honor and it became Lehigh's traditional football rival.

The first bridge across the Lehigh River was built in 1794. It was replaced in 1816, but the latter was destroyed by a flood in 1841. In 1759, the turnpike (toll road) over South Mountain, generally along the route of the present Wyandotte St. hill, was opened. The present Hill-to-Hill Bridge was built some fifty years ago.

"Black gold." During the late 18th century, anthracite was found in the mountains north of the Lehigh Valley. In 1818, the Lehigh Coal Co. and the Lehigh Navigation Co. were formed, one to mine the anthracite on the upper Lehigh River, the other to transport it down river to metropolitan markets.

The Lehigh River was difficult to navigate. Consequently, in 1829 the Lehigh Canal was completed from Mauch Chunk (now Jim Thorpe), through Bethlehem to Easton, where it connected with the Delaware Canal. During the 1840s, iron mines were opened in the area, and several blast furnaces, fueled by coal, were in operation. Zinc ore, was found in neighboring Upper Saucon Township. In the 1850s Asa Packer built the Lehigh Valley Railroad. These origins eventually led to the heavy industry that continues in the Lehigh Valley today.

When Asa Packer founded Lehigh University in 1865, one of his objectives was to make possible broadly based education for young people of the region, combining the technical skills needed to run the flourishing industry of the Lehigh Valley with a liberal education.

In addition to its role as a steel-making center, Bethlehem today is a major tourist attraction. The Moravian community sets up an elaborate nativity scene and the entire city is decorated with lighting during the holiday period. The Moravian tradition of a single candle (now electric) in each window is widely observed.

Atop South Mountain is a steel tower known as the Star of Bethlehem. During the holiday period, the star's hundreds of bulbs create a 95-foot-high star that can be seen for many miles. The star was the gift to the community of Marion Brown Grace, wife of Eugene Gifford Grace, the steel magnate and president of the university board of trustees.

The community of Bethlehem has a population of approximately 78,000 persons with segments from a variety of nations who retain traditions of their country of origin.

There are five principal independent colleges in the Lehigh Valley besides Lehigh. They are Lafayette, Allentown College of
This section lists the people whose talents and abilities constitute the university's most important resource. Members of the board of trustees contribute their expertise to establish the policies of the university. Also listed are the administration, members of the faculty and staff, and the members of the visiting committees who help to keep courses of instruction current and of maximum value to the students and prospective employers.

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When only the year of the degree is listed, the degree was awarded by Lehigh University.

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Denise M. Blew, corporate secretary and treasurer  
Richard H. Sanders, assistant treasurer

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*Martha E. Marcon*, B.S. ’74, national technical resource partners­insurance, KPMG Peat Marwick  
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*H. Edward Muendel*, B.A. ’64, vice chairman, Stanton Chase International  
*Lane P. Pendleton*, B.A. ’91, managing director and principal, Cairnwood Capital International, Ltd.  
*Carl E. Petillo*, B.S. ’62, president & CEO, Yonkers Contracting Co., Inc.  
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*Lawrence C. Russell*, B.S. ’60, M.B.A. ’63, University of Akron, J.D. ’67, Cleveland-Marshall, president, Information Services Division, UNISYS Corp.  
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*James R. Tanenbaum*, B.A. ’71; M.A. ’72, Tufts University; J.D. ’75, University of Pennsylvania, Partner, Stroock & Stroock & Lavan  
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*Ronald J. Ulrich*, B.S. ’67; M.B.A. ’71, New York University, president, Equinox Capital Management  
*Richard R. Verma*, B.S. ’90, Steptoe & Johnson  
*H. A. Wagner*, B.S. Stanford University; M.B.A. Harvard, chairman of the board, president and chief executive officer, Air Products and Chemicals, Inc.  
*Frank E. Walsh*, Jr., B.S. ’63, chairman, Sandy Hill Foundation  
*Joseph F. Welch*, B.S. ’56, chairman & CEO, The Bachman Company  
*E. Belvin Williams*, B.A. ’55, Denver University; M.A. ’57, Professional Diploma-Clinical Psychologist ’62, Columbia University Teacher’s College; Ph.D. ’62, Columbia University; M.S. ’70, Columbia University Graduate School of Business, executive director, Turrell Fund  
*Susan C. Yee*, B.S. ’82, president, Regional Network Communications, Inc.  
*Robert E. Zollner*, B.S. ’54, president, Alpine Associates  

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*Ronald R. Hoffman*, B.S. ’54, executive vice president-human resources, Aluminum Co. of America  
*Philip R. Peller*, B.S. ’60, partner, Andersen World Wide  
*Frank C. Rabold*, B.S. ’39, Eng. D. ’70, retired manager of corporate services, Bethlehem Steel Corp.  
*Stanley M. Richman*, B.S. ’55, president, Lightning Service Electric Co.  
*S. Murray Rust*, Jr., B.S., in M.E. ’34, retired chairman of the board, Rust Engineering Co.  
*Richard M. Smith*, B.S. ’48, LL.D. ’83, retired vice chairman, Bethlehem Steel Corporation  
*James B. Swenson*, B.B.A. ’59, retired partner, Price Waterhouse  
*Edward G. Uhl*, B.S. ’40, Honorary Doctorate of Science ‘75; Easton Ford Company
Principal Officers

Educational information (degrees earned and colleges and universities attended) may be found in the alphabetical listing that follows in this section. The highest degree earned is given here. All offices, unless otherwise noted, are located at Bethlehem, PA 18015; the area code, unless otherwise noted, is (610).

Principal Officers

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Nelson G. Markley, Ph.D., provost and vice president for academic affairs; 758-3605
Rhonda I. Gross, M.B.A., vice president for finance and administration; 758-3178
Robert M. Holcombe, M.B.A., interim vice president for advancement; 758-5351
Bobb Carson, Ph.D., Herbert and Ann Siegel dean, College of Arts and Sciences; 758-4570
Richard M. Durand, Ph.D., Herbert E. Ehlers dean, College of Business and Economics; 758-6725
Roland K. Yoshida, Ph.D., dean, College of Education; 758-3221
John C. Chen, Ph.D., dean, P.C. Rossin College of Engineering and Applied Science; 758-5308
John W. Smeaton, Ph.D., vice provost for student affairs; 758-3890
Donald M. Bolle, Ph.D., interim vice provost for information resources; 758-3025
Lorna J. Hunter, B.S., dean of admissions and financial aid; 758-3101
James A. Tiefenbrunn, M.B.A., associate vice president for resource management; 758-4204
Anthony L. Corallo, M.A., associate vice president for facilities services and campus planning; 758-3970
Denise M. Blew, B.S., CMA, CPA, treasurer and secretary to the board; 758-3179
Joseph D. Sterrett, Ed.D, executive director of athletics; 758-4320

College Offices

College of Arts and Sciences
Maginnes Hall
9 West Packer Avenue; 758-3300
Bobb Carson, Ph.D., Herbert and Ann Siegel dean
Gary G. DeLeo, Ph.D., associate dean
Alexander M. Doty, Ph.D., associate dean
Ingrid Parson, Ed.D., associate dean, graduate and research programs

College of Business and Economics
Rauch Business Center
621 Taylor Street; 758-3400
Richard M. Durand, Ph.D., Herbert E. Ehlers dean
Therese A. Maskulka, D.B.A., associate dean and director, undergraduate program
Kathleen A. Trexler, M.B.A., associate dean and director, MBA program

College of Education
Iacocca Hall
111 Research Drive; 758-3225
Roland K. Yoshida, Ph.D., dean

P.C. Rossin College of Engineering and Applied Science
Packard Laboratory
19 Memorial Drive West; 758-4025

Admissions
27 Memorial Drive West; 758-3100
Lorna J. Hunter, dean of admissions and financial aid

Advancement
27 Memorial Drive West; 758-3120
Robert H. Holcombe, interim vice president for development
John VanNess, associate vice president for development
Nancy K. Westwood, executive director of advancement relations
Richard Santoro, executive director for annual and special campaigns
Alicia Conners, executive director of development operations
James Armfield, executive director of major gifts

Alumni Association
27 Memorial Drive West; 758-3135
Barbara A. Turanchik, executive director

Athletics
641 Taylor Street; 758-4300
Joseph D. Sterrett, executive director of athletics

Ben Franklin Technology Center
125 Goodman Drive; 758-5200
Mark S. Lang, executive director

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9 West Packer Avenue; 758-3375
Michael J. King, director

Business Services
203 East Packer Avenue; 758-3840
Barry L. Gaal, assistant vice president

Career Services
621 Taylor Street; 758-6845
Donna L. Goldfeder, director

Child Care Center
5 Duh Drive; 758-5437
Kathy N. Calabrese, director

Community and Government Relations
428 Brodhead Avenue; 758-4204
James A. Tiefenbrunn, associate vice president for resource management
Stephen J. Gutman, budget manager

Computer Center (see Information Resources)

Conference Services
63 University Drive; 758-5306
Mary Kay Baker, manager

Controller's Office
27 Memorial Drive West; 758-3140
Robert E. Siegfried, controller

Controller's Office
27 Memorial Drive West; 758-3135

Lorna J. Hunter, dean of admissions and financial aid

Advancement
27 Memorial Drive West; 758-3120
Robert H. Holcombe, interim vice president for development
John VanNess, associate vice president for development
Nancy K. Westwood, executive director of advancement relations
Richard Santoro, executive director for annual and special campaigns
Alicia Conners, executive director of development operations
James Armfield, executive director of major gifts

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27 Memorial Drive West; 758-3135
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641 Taylor Street; 758-4300
Joseph D. Sterrett, executive director of athletics

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Mark S. Lang, executive director

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9 West Packer Avenue; 758-3375
Michael J. King, director

Budget Office
428 Brodhead Avenue; 758-4204
James A. Tiefenbrunn, associate vice president for resource management
Stephen J. Gutman, budget manager

Bursar
27 Memorial Drive West; 758-3160
Craig F. Wood, bursar

Business Services
203 East Packer Avenue; 758-3840
Barry L. Gaal, assistant vice president

Career Services
621 Taylor Street; 758-6845
Donna L. Goldfeder, director

Center for Writing, Math and Study Skills
35 Sayre Drive; 758-3098
Edward E. Lotto, director

Chaplaincy Services
36 University Drive; 758-3877
Rev. Dr. Lloyd H. Steffen, university chaplain and professor of religion studies

Child Care Center
5 Duh Drive; 758-5437
Kathy N. Calabrese, director

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428 Brodhead Avenue; 758-4204
James A. Tiefenbrunn, associate vice president for resource management
Stephen J. Gutman, budget manager

Computer Center (see Information Resources)

Conference Services
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Mary Kay Baker, manager

Controller's Office
27 Memorial Drive West; 758-3140
Robert E. Siegfried, controller

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Gary G. DeLeo, Ph.D., associate dean
Alexander M. Doty, Ph.D., associate dean
Ingrid Parson, Ed.D., associate dean, graduate and research programs

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621 Taylor Street; 758-3400
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Kathleen A. Trexler, M.B.A., associate dean and director, MBA program

College of Education
Iacocca Hall
111 Research Drive; 758-3225
Roland K. Yoshida, Ph.D., dean

P.C. Rossin College of Engineering and Applied Science
Packard Laboratory
19 Memorial Drive West; 758-4025

John C. Chen, Ph.D., dean
Philip A. Blythe, Ph.D., associate dean
Richard N. Weisman, Ph.D., associate dean

Offices and Resources

In this section, only the principal officers, are listed. For degree information, consult the alphabetical listing that follows.

Admissions
27 Memorial Drive West; 758-3100
Lorna J. Hunter, dean of admissions and financial aid

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27 Memorial Drive West; 758-3120
Robert H. Holcombe, interim vice president for development
John VanNess, associate vice president for development
Nancy K. Westwood, executive director of advancement relations
Richard Santoro, executive director for annual and special campaigns
Alicia Conners, executive director of development operations
James Armfield, executive director of major gifts

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Joseph D. Sterrett, executive director of athletics

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Mark S. Lang, executive director

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Michael J. King, director

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428 Brodhead Avenue; 758-4204
James A. Tiefenbrunn, associate vice president for resource management
Stephen J. Gutman, budget manager

Bursar
27 Memorial Drive West; 758-3160
Craig F. Wood, bursar

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Barry L. Gaal, assistant vice president

Career Services
621 Taylor Street; 758-6845
Donna L. Goldfeder, director

Center for Writing, Math and Study Skills
35 Sayre Drive; 758-3098
Edward E. Lotto, director

Chaplaincy Services
36 University Drive; 758-3877
Rev. Dr. Lloyd H. Steffen, university chaplain and professor of religion studies

Child Care Center
5 Duh Drive; 758-5437
Kathy N. Calabrese, director

Community and Government Relations
428 Brodhead Avenue; 758-5801
Kenneth R. Smith, assistant to the president for community and government relations
Barbara B. Caldwell, director of community relations
Henry U. Odi, director of academic outreach

Computing Center (see Information Resources)

Conference Services
63 University Drive; 758-5306
Mary Kay Baker, manager

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27 Memorial Drive West; 758-3140
Robert E. Siegfried, controller
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621 Taylor Street; 758-6845
Carol A. Carpenter, director of corporate relations
Barbara H. Steinbock, director of foundation relations

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Ian T. Bird, director

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Sharon K. Basso, associate dean of students
Jennifer F. Volchko, associate dean of students
David M. Yozzi, associate dean of students
Sharon A. Brown, assistant dean of students
Susan Little Lantz, assistant dean of students
Thomas R. Dubreuil, assistant dean of students

Design (see University Design)
Development (see Advancement)
Distance Education (see Special Academic Programs)
Environmental Health and Safety
616 Brodhead Avenue; 758-4251
Barbara A. Liboch, Director
Facilities Services and Planning
461 Webster Street; 758-3970
Anthony L. Corallo, associate vice president for facilities services and campus planning
Gary A. Falasca, director, office of facilities services
Patricia A. Chase, director, facilities planning and renovations

Finance and Administration
27 Memorial Drive West; 758-3180
Rhonda I. Gross, vice president for finance and administration
Denise M. Blew, treasurer and secretary to the board

Financial Aid
218 W. Packer Avenue; 758-3181
William E. Stanford, director

Fraternity Management Association
219 Warren Square; 758-3888
executive director

Government Relations (see Community and Government Relations)
Health Center
36 University Drive; 758-3870
Susan C. Kitei, M.D., director

Human Resources
428 Brodhead Avenue; 758-3900
James A. Tiefenbrunn, associate vice president for resource management

Information Resources
8A East Packer Avenue; 758-3025
Donald M. Bolle, interim vice provost for information resources
Group leaders:
Susan A. Cady, Administrative, Planning & Advancement Services
Jean W. Farrington, Staff and Resource Development
Timothy J. Foley, Client Services
Roy A. Gruver, Technology Management Services
Joseph P. Lucia, Information Management Services
Christine M. Roysdon, Client Services, Collection Management
Kevin R. Weiner, Advanced Technology Group

Institutional Purchasing
203 East Packer Avenue; 758-3840
Joseph F. Hardenberg, director

Institutional Studies (see Office of the President and Provost)
Internal Audit
27 Memorial Drive West; 758-5012
Robert J. Eichenlaub, director

International Education
5 East Packer Avenue; 758-4859
director of international education

William D. Hunter, director, Global Union
Giselma M. Nansteel, immigration specialist
Casimir M. Sowa, associate director

Libraries (see Information Resources)
Mailing and Printing Services
118 ATLS Drive; 758-5402-Mailing; 758-5408-Printing
Glen H. Strouse, director of mailing and printing services

Manufacturers Resource Center
125 Goodman Drive; 758-5599
Edith D. Ritter, executive director

Office of the President and Provost
27 Memorial Drive West; 758-3155
Gregory C. Farrington, president
Nelson G. Markley, provost
Scott M. Knauft, director of planning and institutional studies

Office of Research and Sponsored Programs
526 Brodhead Avenue; 758-3021
Richard H. Sanders, assistant vice president for research and sponsored programs
Thomas J. Meischel, director

Office of the Vice Provost for Research
422 Brodhead Avenue; 758-5802
William D. Michalery, associate vice provost for research

Parking Services
36 University Drive; 758-3893
Patricia A. Potak, manager

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Provost (see Office of the President and Provost)

Public Affairs (see Community and Government Relations)
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27 Memorial Drive West; 758-3200
Bruce S. Correll, registrar

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Residential Services
63 University Drive; 758-3500
David M. Joseph, director

Risk Management
616 Brodhead Ave.; 758-3899
Richard Freeman, director

Special Academic Programs (Distance and Summer Studies)
36 University Drive; 758-3966; 758-6210
James A. Brown, director

Sports Communications
641 Taylor Street; 758-3174
Glenn A. Hofmann, director

Student Affairs
29 Trembley Drive; 758-3890
John W. Smeaton, vice provost for student affairs

Summer Studies (see Special Academic Programs)
Telecommunications (see Information Resources)
Transportation Services
126 Goodman Drive; 758-4410
Christopher J. Christian, director

Treasurer (see Finance and Administration)
University Design
422 Brodhead Avenue; 758-3015
Marvin Simmons, director of design
Steve Oblas, director of design resources

University Police
36 University Drive, Room 221; 758-4200
Eugene Dax, chief

Zoellner Arts Center
420 East Packer Avenue; 758-5323
Eva Bornstein, executive director

Zoellner Arts Center
Faculty and Staff; Emeriti

The first date after the name is the date of appointment to continuous service on the Lehigh University faculty or staff; the second date, when the first fails to do so, indicates the date of appointment to the present professional rank. Where the name of the institution awarding a high-level degree is not given, the institution is the same one that awarded the previous degree listed. P.E. indicates certification as a professional engineer; C.P.A. indicates certified public accountant. A.P.R. indicates accreditation by Public Relations Society of America. A.T.C. means certified athletic trainer.

A


David W. Ackland (1991), assistant research scientist, department of materials science & engineering.


B


Nicholas W. Balabkins (1957, 1994), professor emeritus of economics. Dipl.rer.pol., Gottingen (Germany), 1949; M.A., Rutgers, 1953; Ph.D., 1956.


Margie M. Barry (1984, 1997), manager of development information systems.


Ferdinand P. Beer (1947, 1984), university distinguished professor emeritus of mechanical engineering and mechanics. B.S., Geneva (Switzerland), 1933; M.S., 1935; M.S., Paris (France), 1938; Ph.D., Geneva, 1937.


Linda Bell (1981, 1990), assistant director, financial aid.


D


Eugene J. Dax (1963, 1974), chief and director of campus police.


Margaret L. Dennis (1953, 1982), assistant librarian emerita for bibliographic services, Lindenmeyer Library. A.B., Allegheny, 1939; B.S. in L.S., Syracuse, 1940.


Andrew J. Edmiston (1967), director emeritus of counseling service and professor of education and human services. A.B., West Virginia, 1951; M.S., Miami, 1953; Ph.D., Penn State, 1960.


Mohamed S. El-Aasser (1972, 1996), chair and professor of chemical engineering; director, Polymers Interface Center; Center for Polymer Science and Engineering and Emulsion Polymers Institute. B.S., Alexandria (Egypt), 1962; M.S., 1966; Ph.D., McGill, 1972.


Deborah Feldman (1986), senior enterprise information consultant, information resources. B.S., West Chester, 1974.


J

G
Laurie Gostley-Hackett (1987, 1997), program officer, lacocca Institute, and adjunct lecturer of management and marketing. B.A., SUNY at Oswego, 1982; M.S., Miami Univ. of Ohio, 1984.


William J. Johnson (1984), director of external relations. B.A., Manhattan, 1975; A.P.R.


Chaim D. Kaufmann (1986), research engineer, ATLSS. B.S., Lehigh, 1974; M.S., 1976; Ph.D., 1983.


John L. Kemmerer (1966, 1979), purchasing agent emeritus.


Margaret A. Kernsma (1992), manager, office of distance education.


Hollie B. Knauss (1992, 1999), assistant bursar.


Dean Krause (1975, 1982), media specialist.


William B. Leckomby (1946, 1984), director emeritus of intercollege athletics and recreation. B.S., Lawrence, 1939.


Gerald A. Lennon (1979), senior analyst, tech. management.


Carol D. Liedie (1968, 1988), team leader, tech. management.


Peter Mueller (1980), associate professor of civil engineering. Dipl. Ing. (ETH Zurich), 1967; Dr. sc. tech., 1978.


Steven W. Nott (1985), assistant professor of military science. B.A., Wisconsin at Platteville; Captain, U.S. Army.


Preston Parr (1949, 1982), dean emeritus and vice president emeritus for student affairs. B.S., Lehigh, 1943; M.S., 1944.


Patricia A. Potak (1974, 1992), manager, parking services.


Q


James J. Ricles (1992), professor associate of civil engineering. B.S., Texas, 1979; M.S., Ph.D., California at Berkeley, 1987; P.E., California.


R


Carolyn J. Simmons (1993), assistant professor of marketing.


James P. Sinz (1998), program director, government marketing assistance program, SBDC.


Pamela Steigerwalt (1986, 1988), business manager, information resources.


James E. Sturm (1956, 1995), professor emeritus of chemistry. B.A., St. John’s (Minnesota), 1951; Ph.D., Notre Dame, 1957.


William Warfield (1996), assistant professor of music. B.Mus., Manhattan School of Music; M.M.


Fred J. Wehen (1977), senior computing consultant, information resources.


Research Organizations/ Directors and Staff

Directors and staff members of the university’s research centers and institutes are listed. Complete degree information may be found in the faculty and staff alphabetical listings. In some cases, areas of research interest are given.

All addresses are Bethlehem, Pa. 18015, and the area code is (610).

Biopharmaceutical Technology Institute
111 Research Drive; 758-5427

Building and Architectural Technology Institute
17 Memorial Drive, East;
David C. Amidon, Jr., M.A.; Lynn S. Beedle, Ph.D.; George C. Driscoll, Ph.D.; Francis A. Harvey, Ed.D.; Roy C. Herrenkoh, Ph.D.; Donald J. Hillman, Ph.D.; Ti Huang, Ph.D.; Celal N. Kostem, Ph.D.; Le-Wu Lu, Ph.D.; Benjamin F. Marcuse; Peter Mueller, Dr.sc.techn.; Tom F. Peters, Dr.sc.techn.; Warren A. Pillsbury, Ph.D.; Richard Roberts, Ph.D.; Roger D. Simon, Ph.D.; Steven Thode, D.B.A.; Bruce Thomas, Ph.D.; John L. Wilson, Ph.D.; Ivan Zaknic.

Center for Innovation Management Studies
621 Taylor Street; 758-3427
Al Bean, Ph.D., director; Theodore W. Schlie, Ph.D., associate director for research.

Center for Manufacturing Systems Engineering
200 W. Packer Avenue; 758-5157

Center for Polymer Science and Engineering
111 Research Drive; 610-758-3590

Center for Social Research
516-520 Brodhead Ave.; 758-3800
Diane Hyland, Ph.D., director; Brenda P. Egolf, M.A., research scientist; John B. Gatewood, Ph.D.; Ellen C. Herrenkoh, Ph.D., research scientist; Roy C. Herrenkoh, Ph.D.; Judith N. Lasker, Ph.D.; Carole Reese, M.A., research scientist; M. Jean Russo, Ph.D., research scientist; David B. Small, Ph.D.; Joan Z. Spade, Ph.D.; Lori Toedter, Ph.D.; S. Lloyd Williams, Ph.D.

Chemical Process Modeling and Control Research Center
111 Research Drive; 758-4781

Diamond Center for Economic Education
621 Taylor Street; 758-3401
Jon T. Innes, director

Emulsion Polymers Institute
111 Research Drive; 610-758-3590

Energy Research Center
117 ALSS Drive; 758-4090

Administration, Faculty and Staff
Engineering Research Center for Advanced Technology for Large Structural Systems (ATLSS)
117 ATLSS Drive, Imb Laboratory, Mountaintop Campus; 610-758-5353, Fax 610-758-5553; www.lehigh.edu/atlss
John W. Fisher, Ph.D., co-director; John E. Bower, Ph.D.; Eric J. Kaufmann, Ph.D., metallurgy and materials science; Bruce A. Laub, M.B.A., business and financial services; Le-Wu Lu, Ph.D., seismic design technology; William D. Michalerya, M.B.A., executive director-PTTA; James M. Ricles, Ph.D., structural renewal technology; Richard Sause, Ph.D., structural assemblies and materials; Frank E. Stokes, M.S., manager of structural laboratories; John L. Wilson, Ph.D., computing technology.

Iacocca Institute
111 Research Drive; 758-6723
Dr. Patti Ota, dean, College of Business, Economics; Emory W. Zimmers, Jr., P.C. Rossin College of Engineering and Applied Science; Richard Brandt, Director, Global Village Program; Christine M. Penne, Program Development Officer - Global Village; Sherry L. Buss, Program Development Officer-Iacocca Scholars Program. Iacocca Professors: Mohamed El-Aasser, professor of chemical engineering; Sharon Friedman, professor of journalism and communications; Perry A. Zirkel, professor of education and human services.

Institute of Biomedical Engineering and Mathematical Biology
17 Memorial Drive, East; 758-3703
Eric P. Salathe, Ph.D., director; George A. Arangio, M.D., visiting research scientist; Russell E. Benner, Ph.D., research scientist.

Institute for Metal Forming
5 E. Packer Avenue; 610-758-4252
Wojciech Z. Mistoilek, Ph.D., director, Arelan J. Hansen, John P. Coulter, Ph.D., John DuPont, Ph.D., Albert R. Marder, Ph.D., Michael Rex, Guruswami Sathyarayanav, Ph.D., David B. Williams, Ph.D.

Institute of Fracture and Solid Mechanics
19 Memorial Drive, West; 758-4130
Fazil Erdogan, Ph.D.; Ronald I. Hartanzt, Ph.D.; Robert A. Lucas, Ph.D.; Herman R. Nied, Ph.D., director; Richard Roberts, Ph.D.; Robert P. Wei, Ph.D.

Institute of Thermo-Fluid Engineering and Science
111 Research Drive; 758-4091

Lawrence Henry Gipson Institute for Eighteenth-Century Studies
9 W. Packer Avenue; 758-3369 / 3360
Scott Paul Gordon, Ph.D., co-director; Jean R. Soderlund, Ph.D., co-director; Michael G. Baylor, Ph.D.; Bobb Carson, Ph.D., Marie-Helene Chabut, Ph.D.; Stephen H. Cuthiffe, Ph.D.; Jan Fergus, Ph.D.; Edward J. Gallagher, Ph.D.; Richard K. Matthews, Ph.D.; Philip A. Metzger, Ph.D.; James S. Saeger, Ph.D.; William G. Shade, Ph.D.

Philip and Muriel Berman Center for Jewish Studies
9 W. Packer Avenue; 758-4869, fax 758-4838
Laurence J. Silberstein, Ph.D., director; Robert Cohn, Ph.D. (Lafayette College), Chava Weissler, Ph.D. Associated faculty:

Philip C. Amidon, Jr., M.A.; Daniela Cohen, M.A.; Alice Eckhardt, M.A.; professor emerita; Oles M. Smolansky, Ph.D.; Roslyn Weiss, Ph.D.; Benjamin G. Wright III, Ph.D.

Martindale Center for the Study of Private Enterprise
621 Taylor Street, 758-4771

Materials Research Center
5 E. Packer Avenue; 758-3850
Martin P. Harmer, Ph.D., director; Lisa Friedersdorf, materials industrial liaison program; Hugo Caram, Ph.D., ceramics research laboratory; G. Slade Cargill, Ph.D., thin films laboratory; Helen M. Chan, Ph.D., director, ceramics research laboratory; Manoj Chaudhury, Ph.D., microelectronic packaging laboratory; John Chen, Ph.D., microelectronic packaging laboratory; Richard Decker, Ph.D., microelectronic packaging laboratory; J. Alwyn Eades, Ph.D., director, electro-optical laboratory; Fazil E. Erdogan, Ph.D., ceramic research laboratory; Greg Ferguson, Ph.D., microelectronic packaging laboratory; Gary Harlow, Ph.D., microelectronic packaging laboratory; Miltidis Hatalis, Ph.D., thin films research laboratory; Richard W. Hertzberg, Ph.D., mechanical behavior laboratory; Himanshu Jain, Ph.D., ceramics research laboratory; Charles E. Lyman, Ph.D., electron optical laboratory; Wojciech Mistoilek, Ph.D., microelectronic materials; Herman Nied, Ph.D., microelectronic packaging laboratory; Michael R. Notis, Ph.D., environmental materials laboratory; Sibel Pamukcu, Ph.D., ceramics research laboratory; Raymond A. Pearson, Ph.D., director, microelectronic packaging laboratory; Jeffrey Rickman, Ph.D., modeling research laboratory; Maria Santore, Ph.D., microelectronic packaging laboratory; Arup K. Sengupta, Ph.D., environmental materials laboratory; Gary Simmons, Ph.D., microelectronic packaging laboratory; Donald M. Smyth, ceramics research laboratory; Leslie H. Sperling, Ph.D., director, engineering polymers laboratory; David Thomas, Ph.D., mechanical behavior laboratory; Jean Toulouse, Ph.D., ceramics research laboratory; Richard Vini, Ph.D., director, mechanical behavior laboratory; Arkady Voloshin, Ph.D., microelectronic packaging laboratory; David B. Williams, Ph.D., electron optical laboratory.

Murray H. Goodman Center for Real Estate Studies
621 Taylor Street; 758-4557
Stephen F. Thode, DBA, director.

Mussur Center for Entrepreneurship
621 Taylor Street; 758-3980
John W. Bonge, Ph.D., director; Small Business Development Center, Sandra F. Holsonback, M.B.A., director; John E. Stevens, Ph.D., chair, department of management and marketing; Mary Beth Zingone, L.P.N., associate director; Kim Edwards, B.S.Ed., program director, financing assistance program; Jim Sinz, M.A., program director, government marketing assistance program; Catherine P. Spillman, M.B.A., program director, international trade development program; Cora Landis, lexnet coordinator; Denise von Funk, M.B.A., program administrator, Lehigh-Northampton revolving loan fund.
Polymer Interfaces Center
111 Research Drive; 610-758-3701
Manoj K. Chaudhury, Ph.D., director; Eric S. Daniels, Ph.D.; Victoria L. Dimonie, Ph.D.; Mohamed S. El-Aasser, Ph.D.; Gregory Ferguson, Ph.D.; Daniel C. Hong, Ph.D.; Andrew Klein, Ph.D.; Marie Messmer, Ph.D.; H. Daniel Ou-Yang, Ph.D.; Raymond A. Pearson, Ph.D.; James E. Roberts, Ph.D.; Maria Santore, Ph.D.; Olga L. Shaffer, M.S.; Cesar A. Sitebi, Ph.D.; Gary W. Simmons, Ph.D.; Leslie H. Sperling, Ph.D.

Rauch Center for Business Communications
621 Taylor Street; 758-4863
John W. Bonge, Ph.D., interim director; Sharon Kimmel, M.H.A., program coordinator.

Sherman Fairchild Center for Solid-State Studies
16A Memorial Drive, East
Michael Stavola, Ph.D.; Gary G. DeLeo, Ph.D.; W. Beall Fowler, Ph.D.; Miltiadis Hatalis, Ph.D.; James Hwang, Ph.D.; Ralph Jacobcine, Ph.D., Sherman Fairchild Professor of Solid State Studies; Jerome Licini, Ph.D.; H. Daniel Ou-Yang, Ph.D.; Jean Toulouse, Ph.D.; Marvin H. White, Ph.D., Sherman Fairchild Professor of Solid-State Studies; George D. Watkins, Ph.D., Sherman Fairchild Professor of Solid-State Studies; Donald R. Young, Ph.D.

Small Business Development Center
(see Musser Center for Entrepreneurship)

Science, Technology and Society Program and Technology Studies Resource Center
9 W. Packer Avenue; 758-3350
Stephen H. Cutcliffe, director, Rosemarie Arbur, English; Henri J. Barkey, international relations; Alden S. Bean, management and marketing; Gordon Bearn, philosophy; Lynn S. Beedle, civil engineering; Susan Cady, information resources; Gail Cooper, history; Jack A. DeBellis, English; Robin Dillon, philosophy; Edward B. Evenson, geological sciences; Sharon M. Friedman, journalism; Edward J. Gallagher, English; Norman J. Girardot, religion studies; Steven L. Goldman, philosophy and history; Michael P. Groover, industrial engineering; Francis A. Harvey, education; Ned D. Heindel, chemistry; Roy C. Herrenkohl, social relations; Chaim D. Kaufmann, international relations; Kenneth L. Kraft, religion studies; Judith N. Lasker, social relations; Benjamin Litt, management and marketing; John R. McNamara, economics; Anne S. Meltzer, earth and environmental sciences; Philip A. Metzger, Linderman Library; Jeffrey Miley, speech and theater; Vincent G. Munley, economics; Roger N. Nagel, computer science and electrical engineering; Michael R. Notis, materials science and engineering; Anthony O’Brien, economics; Alan W. Pence, materials science and engineering; Tom F. Peters, art and architecture; Michael Raposa, religion studies; Christine M. Roysdon, Linderman Library; William E. Schiesser, chemical engineering; Keith J. Schray, chemistry; Roger D. Simon, history; Bruce M. Smackey, management and marketing; Robert E. Rosenwein, social relations and classical studies; David Small, social relations and classical studies; John K. Smith, history; Bruce Thomas, art and architecture; Ricardo Viera, art and architecture; Todd Watkins, economics; Albert H. Wurth, government; Raymond F. Wylie, international relations; Ivan Zaknic, art and architecture; Peter K. Zeitler, earth and environmental sciences.

Zettelmeyer Center for Surface Studies
7 Asa Drive; 758-3600, FAX 758-6555
Richard G. Herman, Ph.D., executive director; Manoj K. Chaudhury, Ph.D., associate professor of chemical engineering; Gregory S. Ferguson, Ph.D., associate professor of chemistry; Natalie Foster, Ph.D., associate professor of chemistry; Michael S. Freund, Ph.D. assistant professor of chemistry; James C.M. Hwang, Ph.D., professor of electrical engineering and computer science; Leonard E. Klebanoff, Ph.D., professor of chemistry and director, surface magnetism laboratory; Kamil Klier, Ph.D., professor and director, catalysis laboratory; John W. Larsen, Ph.D., professor of organic chemistry; Charles E. Lyman, Ph.D., professor of materials science and engineering; Marie Messmer, Ph.D., assistant professor of chemistry and director, nonlinear spectroscopy laboratory; Fortunato J. Micale, Ph.D., professor (emeritus) of chemistry and director, colloid laboratory; Alfred C. Miller, Ph.D., director, XPS laboratory; Carl O. Moses, Ph.D., associate professor of earth and environmental sciences; Steven L. Regen, Ph.D., professor of organic and polymer chemistry; James E. Roberts, Ph.D., associate professor of chemistry; Gary W. Simmons, Ph.D., professor of chemistry and director, surface analysis laboratory; Israel E. Wachs, Ph.D., professor of chemical engineering and director, vibrational spectroscopy laboratory; Robert P. Wei, Ph.D., professor and director, environment-sensitive fracture laboratory.

Research Scientists: Xingtao Gao, Ph.D.; Richard G. Herman, Ph.D.; Eugene S. Ilton, Ph.D.; Thomas Lloyd, Ph.D.; Alfred C. Miller, Ph.D.


Technical Associate: Jean S. Lavelle.
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<td>August 25-26 (Wednesday-Thursday)</td>
<td>Graduate Registration</td>
</tr>
<tr>
<td>August 27-29 (Friday-Sunday)</td>
<td>Freshman Orientation, Freshman Registration</td>
</tr>
<tr>
<td>August 30 (Monday)</td>
<td>Undergraduate Registration</td>
</tr>
<tr>
<td>August 31 (Tuesday)</td>
<td>Classes begin; last day for graduate registration</td>
</tr>
<tr>
<td>September 6 (Monday)</td>
<td>Labor day classes held</td>
</tr>
<tr>
<td>September 7 (Tuesday)</td>
<td>Last day to add courses without instructor's signature</td>
</tr>
<tr>
<td>September 13 (Monday)</td>
<td>Last day for fall registration; last day to drop a course without a &quot;W&quot;</td>
</tr>
<tr>
<td>September 20 (Monday)</td>
<td>Last day to select or cancel pass/fail grading; Yom Kippur</td>
</tr>
<tr>
<td>September 29 (Wednesday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>September 30 (Thursday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>October 5 (Tuesday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>October 6 (Wednesday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>October 9-12 (Saturday-Tuesday)</td>
<td>Pacing Break - no classes</td>
</tr>
<tr>
<td>October 13 (Wednesday)</td>
<td>Classes resume; Monday classes meet</td>
</tr>
<tr>
<td>October 25 (Monday)</td>
<td>Mid-semester reports due</td>
</tr>
<tr>
<td>November 1 (Monday)</td>
<td>Last day to file applications for January degree</td>
</tr>
<tr>
<td>November 8 (Monday)</td>
<td>Last day for January doctoral candidates to deliver approved dissertation drafts to the appropriate college dean's office</td>
</tr>
<tr>
<td>November 8-12 (Monday-Friday)</td>
<td>Preregistration for Spring 2000</td>
</tr>
<tr>
<td>November 10 (Wednesday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>November 11 (Thursday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>November 16 (Tuesday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>November 17 (Wednesday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>November 18 (Thursday)</td>
<td>Last day to withdraw from a course with a &quot;W&quot;</td>
</tr>
<tr>
<td>November 25-28 (Thursday-Sunday)</td>
<td>Thanksgiving Vacation</td>
</tr>
<tr>
<td>December 3 (Friday)</td>
<td>Last day for hourly exams</td>
</tr>
<tr>
<td>December 6 (Monday)</td>
<td>Last day for January master's degree candidates to submit unbound thesis copies to the Registrar's Office</td>
</tr>
<tr>
<td>December 10 (Friday)</td>
<td>Last day of classes; last day to drop a course with a &quot;WP&quot; or &quot;WF&quot;</td>
</tr>
<tr>
<td>December 11 (Saturday)</td>
<td>Review-consultation-study period for Tuesday classes</td>
</tr>
<tr>
<td>December 13 (Monday)</td>
<td>Review-consultation-study period for Monday classes; last day for January doctoral degree candidates to complete all degree requirements</td>
</tr>
<tr>
<td>December 14 (Tuesday)</td>
<td>Final exams begin</td>
</tr>
<tr>
<td>December 22 (Wednesday)</td>
<td>Final exams end</td>
</tr>
</tbody>
</table>

### SPRING 2000

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 6-7 (Thursday-Friday)</td>
<td>Graduation Registration</td>
</tr>
<tr>
<td>January 9 (Sunday)</td>
<td>Commencement</td>
</tr>
<tr>
<td>January 17 (Monday)</td>
<td>Undergraduate Registration</td>
</tr>
<tr>
<td>January 18 (Tuesday)</td>
<td>Classes begin; last day for graduate registration</td>
</tr>
<tr>
<td>January 24 (Monday)</td>
<td>Last day to add courses without instructor's signature</td>
</tr>
<tr>
<td>January 31 (Monday)</td>
<td>Last day for spring registration; last day to drop a courses without a &quot;W&quot;</td>
</tr>
<tr>
<td>February 7 (Monday)</td>
<td>Last day to select or cancel pass/fail grading</td>
</tr>
<tr>
<td>February 16 (Wednesday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>February 17 (Thursday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>February 19-22 (Saturday-Tuesday)</td>
<td>Pacing break - no classes</td>
</tr>
<tr>
<td>February 23 (Wednesday)</td>
<td>Classes resume, Monday classes meet</td>
</tr>
<tr>
<td>February 24 (Thursday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>February 29 (Tuesday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>March 1 (Wednesday)</td>
<td>Last day for filing applications for June graduation</td>
</tr>
<tr>
<td>March 13 (Monday)</td>
<td>Mid-semester grades due</td>
</tr>
<tr>
<td>March 18-26 (Saturday-Sunday)</td>
<td>Spring break</td>
</tr>
<tr>
<td>March 30 (Thursday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>April 4 (Tuesday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>April 5 (Wednesday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>April 6 (Thursday)</td>
<td>Four o'clock quizzes</td>
</tr>
<tr>
<td>April 10-14 (Monday-Friday)</td>
<td>Preregistration for Summer 2000 and Fall 2000</td>
</tr>
<tr>
<td>April 12 (Wednesday)</td>
<td>Last day to withdraw from a course with a &quot;W&quot;</td>
</tr>
<tr>
<td>April 20-24 (Thursday-Monday)</td>
<td>Easter break/Passover - no classes</td>
</tr>
<tr>
<td>April 25 (Tuesday)</td>
<td>Classes resume; last day for June doctoral candidates to deliver approved dissertation drafts to the appropriate college dean's office</td>
</tr>
<tr>
<td>May 1 (Monday)</td>
<td>Last day for hourly exams</td>
</tr>
<tr>
<td>May 4 (Thursday)</td>
<td>Last day for June master's candidates to submit unbound thesis copies to the Registrar's Office</td>
</tr>
<tr>
<td>May 5 (Friday)</td>
<td>Last day for June doctoral candidates to complete all degree requirements</td>
</tr>
<tr>
<td>May 8 (Monday)</td>
<td>Last day of classes; last day to drop a course with a &quot;WP&quot; or &quot;WF&quot;</td>
</tr>
<tr>
<td>May 9 (Tuesday)</td>
<td>Review-consultation-study period for Tuesday classes</td>
</tr>
<tr>
<td>May 10 (Wednesday)</td>
<td>Review-consultation-study period for Monday classes</td>
</tr>
<tr>
<td>May 11 (Thursday)</td>
<td>Final exams begin</td>
</tr>
<tr>
<td>May 19 (Friday)</td>
<td>Final exams end</td>
</tr>
<tr>
<td>June 4 (Sunday)</td>
<td>University Commencement Day</td>
</tr>
</tbody>
</table>