1995-96 Catalog

Advancing Life-Long Learning

LEHIGH University
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 in virtually all major programs. 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.

American Studies  Engineering Mechanics
Anthropology  Engineering Physics
Architecture  English
Art  Environmental Sciences
Behavioral Neuroscience  French
Biochemistry  Fundamental Sciences
Biology  Geology
Chemical Engineering  Geological Sciences
Chemistry  Geophysics
Civil Engineering  German
Civil Engineering/Geological Sciences  Government
Classical Civilization  History
Classics  Industrial Engineering
Cognitive Science  Interdisciplinary Studies
Computer Engineering  International Careers
Computer Science  International Relations
East Asian Studies  Journalism
Economics  Journalism/Science Writing
Electrical Engineering  Materials Science and Engineering
Electrical Engineering  Mathematics
/Engineering Physics
Mechanical Engineering
Molecular Biology
Music
Natural Science
Philosophy
Physics
Predental Science
Premedical Science
Psychology
Religion Studies
Russian Studies
Science, Technology and Society
Sociology/Social Psychology
Social Relations
Spanish
Statistics
Theatre
Urban Studies

Academic Departments

College of Arts and Science  College of Business and Economics  College of Education  College of Engineering and Applied Science
Art and Architecture  Business  Education  Chemical Engineering
Biological Sciences  Economics  Engineering
Chemistry  History  Civil Engineering
Earth and Environmental Sciences  International Relations  Electrical Engineering
English  Journalism
Government  Communication
History  Industrial and Manufacturing
Interdisciplinary Studies  Systems Engineering
Journalism and Communication  Materials Science and Engineering
Mathematics  Mechanical Engineering
Modern Foreign Languages  and Mechanics
Music  Philosophy
Philosophy  Physics
Psychology  Theatre
Religion Studies  Urban Studies
Sociology/Anthropology  Lehigh University reserves the right at any time to change the rules and regulations governing admission, tuition, fees, regulations affecting its students.
Location
Founded in 1865 in Bethlehem, Pa., Lehigh University is less than two hours from New York City, Philadelphia, the Pocono Mountains and the New Jersey shore. Historic Bethlehem, settled in 1741, is one of three cities of the Lehigh Valley, Pennsylvania's fourth-largest metropolitan area. It is served by Lehigh Valley International Airport, located 15 minutes from campus.

Students
Approximately 4,300 undergraduates (63% men, 37% women and 10% minorities) come from nearly every state and more than 40 foreign countries. There are about 2,000 graduate students.

Total Enrollment

<table>
<thead>
<tr>
<th>College</th>
<th>% Undergraduates</th>
<th>College</th>
<th>% Graduate Students</th>
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<td>Education (graduate</td>
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<td>only)</td>
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</tr>
</tbody>
</table>
Colleges and Majors
Undergraduates may select from more than 70 majors in the College of Arts and Sciences, Business and Economics and Engineering and Applied Science, which offer bachelor’s, master’s and doctoral degree programs. The College of Education offers graduate degree programs only.

Graduation Rate
85% of Lehigh undergraduates earn degrees within five years. Nationally, 53% earn degrees within five years.

Faculty
Among 410 professors, 99% hold the highest degree in their field. The ratio of undergraduates to full-time faculty is 11 to 1.

Alumni Loyalty
About 55% of Lehigh alumni contribute to their alma mater, a record of giving that is third highest among major American private universities.

Mission and Vision
Lehigh University’s mission is to advance learning through the integration of teaching, research and service to others. This principle of intellectual integration is as suited today as it was for the late 19th century, when Lehigh’s founders defined a Lehigh education as the integration of knowledge both technical and classical.

Lehigh promotes the discovery of knowledge, celebrates integrating and communicating that knowledge and applies knowledge to connect thought to action and theory to practice. As the 21st century approaches, Lehigh is even more committed to its unique ability to develop “reflective practitioners,” graduates who can identify, analyze and solve problems throughout their lives in whatever circumstances they find themselves.

This commitment to integrated learning, combined with Lehigh’s relatively small size, enable the university to approach the ideal integration of teaching and research more closely than do most colleges and universities. But Lehigh is striving to improve even more that aspect of the learning process.

Lehigh offers an ideal environment to learn about the rich varieties of cultures, religions and social groups that exist in the world. Lehigh is dedicated to increasing diversity while maintaining a unity and sense of community that is a university hallmark.

To preserve Lehigh’s vision and remain strong even in times of adversity, its management strives to anticipate the external environment in which Lehigh must operate, relies on Lehigh’s competitive advantages and reinforces the standards and values of the university, including a commitment to moral and fiscal integrity.
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. Various College of Education programs are accredited by the National Council for Accreditation of Teacher Education, including Commonwealth of Pennsylvania approval for certification programs. Programs in chemistry are approved by the American Chemical Society.
The department of theatre was accredited by the National Association of Schools of Theatre, recognized by the US 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 of 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 Director of Admissions, conducts a selective review of candidates for admission. Several criteria are used in an attempt to predict a student's ability to do college level work.
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 colleges 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 Admission waive the foreign language requirement for admission to any one of the three undergraduate colleges.

**Waivers of the requirement in mathematics are granted to otherwise well-qualified candidates for admission who propose to major in one of the following fields offered by the College of Arts and Science: American studies, art, classics, theater, English, modern foreign languages, government, history, international relations, journalism, music, philosophy, religion studies, social relations, and urban studies.

Students planning on enrolling in the College of Engineering and Applied Sciences must have studied Chemistry and mathematics through trigonometry, and should have studied Physics and mathematics through pre-calculus. Calculus is recommended. Students planning on enrolling 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 Science preparing for a bachelor of science degree must also take math through trigonometry and candidates for a bachelor of arts degree should take additional language study beyond the two required years of foreign language study.

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 the 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 students selected area of study
- The difficulty of courses taken with special attention paid to courses which are 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.

**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:** Candidate are not required to write any College Board SAT II tests. Students may submit them if they feel they will be helpful to the admissions process.

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 may also be included but is not 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 participate in a campus tour and to meet with an admissions officer for a personal interview. No appointment is necessary for a campus tour, but interviews should 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. During the visit to our campus it is often possible to meet with faculty, coaches, or other professional staff of the university.

The Office of Admissions is open for interviews most weekdays from 9:00 am to 11:15 am and from 1:15 pm to 4:15 pm. Tours are conducted according to the availability of tour guides, but are usually available five 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 March 31 period when the staff is reading files, although exceptions can be made for persons traveling great distances.

In certain cases an interview may be required if, in the opinion of the Director of Admissions, the additional information gained in 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) 758-3100. Students may also use the Common Application available from school guidance counselors. The Common Application is accepted as the equal of the Lehigh application. Applications should be filed according to the following deadlines:
December 1—Early Decision I
December 1—6 year BA/MD Program
January 1—Penn-Dental 7 year Dental Program
January 15—Early Decision II
February 15—Final Application deadline
Each application must be accompanied by an application fee of $40. This fee is non-refundable and does not apply towards the tuition fees. Waivers of application fees are accepted when forwarded on the appropriate forms from the school guidance office. Students for whom the application fee is a hardship should consult the guidance office at their school.

Early Decision
The university will act on early decision applications received by the appropriate deadlines. 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 that they understand that if the student is accepted, and the financial aid package is appropriate, the student is expected to accept our offer and withdraw all other applications. Students applying early should have been to campus for an interview and should be sure that Lehigh is their first choice school. Students who meet the December 1 deadline will be notified before December 31 and those who meet the January 15 deadline will be notified around February 1. It is understood that the student will continue 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 they want 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 package 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 is made by mail between March 15 and April 1. Once a student has been admitted he or she may secure a place in the entering class by notifying the university that they intend to enroll at Lehigh and by forwarding the appropriate admissions deposit by May 1. This fee is applicable towards the tuition and room and board fees for the fall term. Students who fail to enroll or withdraw after depositing 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.

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

Each candidate must submit an official transcript from each institution attended. An admissions decision cannot be made without this information. Students wishing to enter in the spring should apply not 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) 758-3100.

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. Soon after, the student will be notified by the Registrar as to how many credits Lehigh will grant to the student in advanced standing.

Housing: Due to the demand for residence hall housing, the university is unable to automatically guarantee housing to transfer students. Although it is not possible to predict exactly how many housing spaces may be available at the start of any given semester, some space is available in most semesters. Contact the Office of Residential Services, Rathbone Hall, Lehigh University, 63 University Drive, Bethlehem, PA 18015 or by calling (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 Office of Student Life, Coordinator of Greek Affairs, University Center, 27 Trembley Drive, Lehigh University, Bethlehem, PA 18015 or by calling (610) 758-4157.

Advanced Placement
The university offers capable 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 who ask the College Board to send their advanced placement grades to Lehigh are considered for advanced placement. Examination grades range from a low of 1 to a high of 5.

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 admission 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 for 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. Three 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 Chem 21, Chem 22, and Chem 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 chemistry achievement test, are granted five credit hours for Chem 21 and Chem 22 and may apply to the department for a special examination that, if completed successfully, will result in an additional three credit hours for Chem 31.

Computer Science. Students receive three semester credit hours for CSc 11 for a grade of 3. Those students who earn grades of 4 or 5 receive four credit hours for CSc 17 instead of CSc 11.

Economics. Students will receive three credit hours for each of the microeconomics and macroeconomics exams in which a score of 4 or better is awarded.

English. Advanced placement and six credit hours are given for freshman English to students who earn a grade of 5. Students who receive a grade of 4 or who have a score of 700 or higher on the verbal section of the Scholastic Assessments Test or the English Composition Achievement Test receive three hours of credit in freshman English; these students complete the six-hour requirement by taking an English course suggested by the department. Students whose SAT Verbal Aptitude Test or English Composition Achievement score between 650 and 699, or who have received a grade of 3 on the advanced placement test may apply to the department for a special examination given during Freshman Orientation, which, if completed successfully, will result in three hours of credit for Engl 1.

Government and Politics. Three semester credit hours for Government I are given to students who earn grades of 4 or 5.

History. Students who earn grades of 4 or 5 on the American History Test receive six semester hours of credit for Hist 9, 10, Survey of U.S. History I, II. Students who earn grades of 4 or 5 on the European History Test receive three semester hours of credit for Hist 12, Survey of European History II.

Latin. Students receive three semester hours of credit for a grade of 4 or 5 in the Vergil examination; those who successfully write in more than one area (e.g., Vergil and lyric poetry) receive six hours of credit.

Mathematics. Four semester hours of credit for Math 21, Analytic Geometry and 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, Analytic Geometry and 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. This examination may be taken by students regardless of whether they have taken the advanced placement examination or not.

Modern foreign languages. Students receive three semester hours of credit for grades of 4, and six hours of credit for grades of 5 on the advanced placement tests. Those who write the achievement tests and score 600 and above receive three hours of credit; 700 and above receive six hours of credit. The maximum number of credits given is six and will be assigned intermediate level course credit in the appropriate language. 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 20 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. Four credit hours of Psy 1 are granted to students who earn a grade 4 or 5.

International Baccalaureate. Students who earn the international baccalaureate are granted credit in higher-level or advanced subjects in which they earn scores of 5 or higher.

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 $250 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 1,825 students on or near the campus in a wide selection of housing facilities. The housing arrangements are grouped within three basic categories, with rates associated with the category level. Students contracting for residence halls housing will be required to submit a $200 advance deposit for each semester. This deposit is credited toward the room charge for the respective semester. For entering freshmen, the deposit is not refundable if they make other plans. For upperclass students, the fee is either full or partially refundable based upon a published schedule.

The board plan. Four board plans are available. The basic Any-19-Meal Plan is required for all freshman residents. Upperclass students living in residence halls have the option of participating in the Any-10-Meal Plan. Students residing in fraternities, campus apartments, or any off-campus facilities are eligible to participate in any of the plans. The Any-7-Meal Plan is for Centennial I sororities. Subscription to special program meals is required of residential college members.

Tuition and Fees
All charges and fees are due two weeks prior to the start of classes each semester. On a per-term basis, the expenses are charged at one-half the per-year charge. Accounts not settled by the due date are subject to a late-payment fee. All figures given are for the academic year (two semesters).

Tuition, 1995-96 $19,650

Residence Halls
Category I (Dravo, Drinker, Richards, and McClintic-Marshall) $2,890
Category II (Centennial I, Warren Square) $3,260
Category III (Trembley Park, Brodhead House, and Taylor College) $3,490

Board
Any 19 meals per week* $2,550
Any 10 meals per week* $2,250
Any 7 meals per week* $1,590
Any 5 meals per week* $1,380
*Each meal plan includes $100 South Mountain Gold credit.

Based upon the above charges, most freshmen are normally billed the tuition rate along with the Category I or II room fee and any 19 board plan. The total cost for the three areas would be $25,090 for the 1995-96 academic year.

Other Fees (applied to prevailing circumstances)
Per credit charge for credit and audit 820
Engineering and Science Fee (for specified students) 250
Application fee (for undergraduate admission consideration) 40
Late preregistration 50
Late registration 50
Late application for degree 25
Examination make-up (after first scheduled make-up) 10
Late payment (after announced date) 50
Returned check fine 20
Key penalty (non-return), residence halls 10
Key duplicate, building door, residence halls 5
Access card duplicate, residence halls 10
Lost or non-return room key/lock change, residence halls 25
Identification card (replacement) 10

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 1996-97 academic year will be announced no later than January, 1996.

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 Maginnis 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 refunds. 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:

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 refunds. 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:
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 normal 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 tuition. Those who do not receive an invoice are expected to make payment at the time of registration. Registration will not be permitted until all charges are paid. Students in good standing who formally withdraw or reduce their course enrollment within the first four weeks of a summer term will be eligible for a tuition refund. The refund schedule for student withdrawals and course adjustments is as follows:

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Refund Percentage</th>
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</thead>
<tbody>
<tr>
<td>Prior to start of summer session</td>
<td>100%</td>
</tr>
<tr>
<td>During first calendar week</td>
<td>90%</td>
</tr>
<tr>
<td>During second calendar week</td>
<td>60%</td>
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<tr>
<td>During third calendar week</td>
<td>40%</td>
</tr>
<tr>
<td>During fourth calendar week</td>
<td>20%</td>
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</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. 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 semester remaining.

Refunds for board plans. Board refunds are made in full in the event a student does not register because of illness, injury, 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 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 room refund.

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. Nearly 50% of our 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 on Renewal of aid). Students are also expected to advance at a rate of at least 12 credits per semester.

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

As noted, we currently enroll at least 50 percent of the freshman class with financial aid including university-funded scholarships ranging, according to need, from $500 to $22,500. An additional 5 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 are non-repayable forms of aid that can be called either scholarships or grants. Employment provides money for books and personal expenses, and is paid through monthly payroll checks as a student submits time sheets for hours worked. 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 bases of both 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. In addition, Lehigh provides, at no cost, access to the computer-based software called Fund Finder, which operates on our Computing Center PCs. 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 have changed for 1996-97**

The following instruction about filing for financial aid is addressed to prospective freshmen.

To be given proper consideration for financial aid, your application must be complete and ready for review by March 1. That means you must start the application process several weeks earlier. Start the process by registering for PROFILE. A short registration form, available in high school guidance offices, collects basic identifying information about you and asks you to list the colleges and programs from which you are seeking aid. You may also register by telephone. (In some high schools you can register via an electronic network like the College Board's ExPAN.)

List Lehigh University - #2365 on the CSS code list - when you register for PROFILE. That tells CSS you want to apply for aid from our institution. Complete the PROFILE registration process no later than January 5, 1996. That is the date by which we want all financial aid applicants to have registered with CSS. (If you are applying to other colleges with earlier deadlines than ours, give yourself at least four weeks before the earliest date specified by colleges and programs on your list.)

Upon receipt of our registration CSS will send you a personalized PROFILE form as soon as possible and mail it so that it reaches CSS by February 15. Within four weeks CSS will report to us and send an acknowledgment to you. By completing the form promptly, you ensure that your file is complete and ready to review on March 1.

**L. Special note to Early Decision Candidates:**

Lehigh University communicates to early decision candidates within ten days of the Office of Admission's notification. You should register for PROFILE by October 15 (or as soon thereafter as possible) if you are applying for admission under the Early Decision I calendar.

Your packet may contain additional supplements that should be completed and returned directly to the financial aid office. If your parents are divorced or separated and/or if our family owns a farm or business, Lehigh University wants you to complete the appropriate supplement and mail it directly to the financial aid office. (If your packet doesn't contain any additional supplements, that probably means you do not need them. If you have questions, call the office of financial aid.)

If you are a citizen of the United States or a registered alien, Lehigh University expects you to apply for federal student aid. To be considered for federal student aid, including Federal Pell Grants and Federal Stafford Loans, you must complete the Free Application for Federal Student Aid (FAFSA). FAFSAs are available from your high school. You may complete and submit this form anytime after January 1, 1996, but we recommend that you complete it no later than March 1, 1996. The Lehigh University federal code, to be entered on the FAFSA, is 003289.

**Renewal of aid.** It is necessary to reapply for financial aid for each year of study. Applications and filing instructions are available in mid-February in the Office of Financial Aid, or as otherwise posted.

As an upperclassman, you should file the Renewal FAFSA with the federal processor by April 15. You should register for the PROFILE as soon as the applications are made available, completing and mailing customized PROFILE packet by April 15 also. A Lehigh application form must also be completed and returned to the university's Office of Financial Aid by April 15, accompanied by a signed copy of both the parents' and the applicant's 1995 IRS 1040 (with all schedules filed and W-2's), as well as those additional forms required for special circumstances, such as the Divorced/Separated Parent's Statement and the Business and Farm Supplement. Upperclass applications are not reviewed until the FAFSA, PROFILE, Lehigh application and income tax forms are received.

In addition, to receive any type of aid a student must make satisfactory academic progress each year. University policy on satisfactory academic progress is available in the office of financial aid. Recipients of Lehigh grants and scholarships are expected to achieve at least a 2.0 each semester, or as noted on their financial aid notification. (Because our financial aid packaging can differ, with some students receiving less loan and employment in their awards, expected grade point averages, needed for renewal, can vary - some up to a 3.00. Any above the 2.00 are noted on the award notification.) Students on academic or disciplinary probation are ineligible for university scholarship aid during the period of their probation. Students not maintaining satisfactory progress, as defined by Lehigh, are ineligible for all forms of federal aid, including loans and employment. 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.
Sources of University Aid

Several forms of university-funded aid, based on need and merit, are available.

**Lehigh University scholarships.** Funds are budgeted from general income to provide awards covering the full tuition charges of students attending college. Lehigh has 190 such sponsors, with awards ranging from $300 to full tuition.

**Sponsored scholarships.** Individuals, foundations, and corporations provide these funds through annual contributions to the university. Lehigh has over 300 such funds, half of which are for general, unrestricted use. Most of the others are restricted by curriculum or geographic criteria.

*Geographic Restrictions:* Pennsylvania, New Jersey, Delaware, Maryland, Ohio, Massachusetts, Virginia, Colorado, Texas, Georgia, North Carolina, Tennessee, Missouri, Kansas, Richmond, VA, Kansas City, MO, Jackson County, MO, Johnson County, KS, Hammonton, NJ, Allentown, PA, York County, PA, New York City, NY, Baltimore, MD, Western, PA.

*College of Arts and Sciences:* Geology and Geological Science, Premedical Science, Journalism and Science Writing.

*College of Business and Economics:* Accounting, marketing, economics.

*College of Engineering and Applied Sciences:* Applied mathematics, civil engineering, chemical engineering and chemistry, computer science, electrical engineering, industrial engineering, mechanical engineering, metallurgy, physics and engineering physics.

*Miscellaneous:* Musicians (brass instruments); Gryphons; employees of U.S. Steel, Milton Roy Sheen, and Alperin Co.; members of certain fraternities.

**Dean’s scholarships.** Lehigh began, with the Class of 1999, to offer merit awards, called Dean’s Scholarships, in the annual amounts of $5,000 or $7,000. Selections are made by the Office of Admissions based on academic excellence and significant extracurricular and leadership activities.

**Merit scholarships.** Lehigh is a collegiate sponsor of the National Merit Scholarship program. Scholarships ranging from $750 to $2,000 per year may be awarded to Merit finalists selecting Lehigh as their first-choice college, and who are not also receiving another form of National Merit scholarship.

**Athletic awards.** Alumni Student Grants are awarded on the basis of financial need and exceptional athletic talent as evaluated by the department of intercollegiate athletics. Grants are supported by annual alumni contributions. ASG recipients file the FAFSA and PROFILE annually to determine the amount of their grant eligibility. In addition, there are a number of restricted endowed funds for use with intercollegiate sports participants. Alumni Student Grants replace the loan and employment portion of a financial aid package.

**University tuition loans.** Parental endorsement is required on the promissory note. Repayment begins three months after graduation or withdrawal from the university, until the loan principal and interest are repaid. The minimum monthly repayment rate is $50 plus interest, which is 7 percent per annum, accruing only during the repayment period. Deferment is available for students who return to school at least half-time. Other deferments are available for students who are in the military, VISTA, or Peace Corps, up to a maximum of three years; or those who are experiencing undue hardship.

Lehigh maintains these loan funds to be used to supplement or replace other types of educational loans. The guiding factor in awarding university loans is that the combination of loans (federal, state, and institutional) shall not exceed one-half the cumulative tuition to be paid through the award period. If, for example, the total tuition over four years amounted to $72,000, a university loan would not be offered if total borrowing exceeded $36,000.

**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. The specified average must be earned during the term(s) of this award for the loan to be canceled and replaced by a scholarship. The recipient is expected to complete and pass a minimum of twelve (12) credits of new course work each academic period covered by this award, unless otherwise noted by the Committee on Undergraduate Financial Aid. If not canceled, the loan is repayable according to the terms for university tuition loans.

**Availability of jobs**

Students may receive an employment allocation as part of their aid package. Pay rates range from the federal minimum wage to $6.50 per hour. Jobs are available throughout the university, and are funded through federal and university sources.

Earnings from employment, other than work-study work opportunity, will be included as "income" in calculating financial aid eligibility for the next year.
Aid from the government

Lehigh University is an eligible participant in the following federally-funded student aid programs. Direct entitlement programs (where the government directly, or through commercial lenders for loan programs, provides the necessary funds):

- Federal Pell Grants
- Federal Stafford Loans
- Federal Unsubsidized Stafford Loans
- Parent Loan for Undergraduate Students (PLUS)
- Federal Supplemental Educational Opportunity Grants
- Federal Perkins Loans
- Federal Work-Study

Details on these programs are available through the financial aid office. Participants on the loan programs are available from participating lenders.

ROTC scholarships. The U.S. Army awards scholarships in varying amounts, supplemented with an amount to cover course-related books and a $150 per month stipend. Scholarships are also available after the freshman year. Recipients incur an obligation to serve on active duty as commissioned officers. Contact the Department of Military Science for details.

Checklist for Financial Aid

1. For returning students, and transfer applicants, submit the Lehigh application for undergraduate financial aid. Be sure to complete all questions.
2. The Free Application for Federal Student Aid (federal code 003289) must be received by the federal processor on or before February 15 for freshmen to be considered on time. (Returning students file the Renewal FAFSA by April 15.)
3. The PROFILE customized packet must also be received by CSS on or before February 15 to be considered on time. Use CSS college code 2365 in requesting that your information be sent to Lehigh. Returning students, must file by April 15.
4. Submit the appropriate state grant application, especially if you are a resident of Pennsylvania, Ohio, Massachusetts, Connecticut, Rhode Island, Maryland, Delaware, Vermont, or West Virginia—states from which our students have brought scholarships. Be guided by the specific instructions for your state. The FAFSA will be the basic form for state grant consideration, but many states do require supplemental applications.
5. Submit signed copies of the 1995 IRS form 1040, (which must be signed and contain all pages, schedules and W-2s), filed by you and your 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 your social security number is correctly listed on all forms. If you do not have a number, apply for one and notify Lehigh as soon as it is received.
7. For your records, photocopy all forms filed for financial aid purposes.
8. Transfers students: Be sure to have your previous college(s) complete and forward the Financial Aid Transcript. This is a federal mandate, even if you never received financial aid at another school. You, too, must file a FAFSA and PROFILE, together with the Lehigh application, to be considered for university-funded aid. File as close to March 1 as possible. Transfer reviews are completed after decisions are made for the freshman class (normally soon after May 1.)

Student Rights

You have the right to know
- The cost of attendance
- The refund policy for students who withdraw
- The financial assistance available from state, and institutional sources
- Procedures and deadlines for submitting applications for financial aid
- How financial aid recipients are selected
- How your eligibility was determined, including all resources the aid office considered available to you
- How and when funds will be disbursed to you
- An explanation of each type of award you receive
- For any student loan you receive: the interest rate, total amount you must repay, when your repayments begin, the length of your repayment period, and the cancellation or deferment provisions of your loan
- For any Federal Work-Study or university-funded job: a description of the job, the hours you must work, the rate of pay, and how and when you will be paid
- The criteria used to determine satisfactory academic progress for financial aid purposes
- How to appeal a decision by the office of financial aid concerning your aid award.

Student Responsibilities

It is your 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 you are required to sign
- Repay any student loans you may receive
- Attend an entrance interview and an exit interview if you receive federal, state or University loans while in attendance at Lehigh
- Notify the office of financial aid of any change in your 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 your lender if you have a loan
- Satisfactorily perform the work agreed upon in a Federal Work-Study or university-funded work program
- Know and comply with all requirements for continuation of financial aid, including satisfactory academic progress requirements
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 houses or sorority units. 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-class learning in order to enable students to develop a balanced and realistic approach to life after they leave the university.

More than half of Lehigh undergraduates live in university residence halls. The university has nine principal residence halls for undergraduate men and women. Most rooms are designed for two students, but a limited number of single, triple, or suite arrangements, and apartment units, are available. Residence halls offer a wide variety of special live-in programs including: Taylor Residential College, Science and Technology, PenDragon House, Creative Arts House, Umoja House (African-American/Hispanic Cultural), traditional-style living (in buildings with corridors), and suite/apartment-style living.

To help facilitate and maximize a student's residence experience, approximately ninety staff members of the Office of residence life live in the residence halls. On every hall there is a 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 staff, six professional hall directors 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 Hall 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.

Currently, the demand for upperclass campus housing is competitive. 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. Those students who are guaranteed housing pay a $200 deposit to hold the space for the following academic year.

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 of assignment is based on date of receipt of this application. A nonrefundable advance deposit of $200 must accompany the application and will be credited to the fall semester room charges. Normally, freshmen are informed of their room assignment and other information in early August by the Office of Residential Services.

Fraternities and Sororities

The university has one of the strongest Greek systems in the nation. The continued growth 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, the Office of Student Life, and the Fraternity Management Association 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 a relatively small, close-knit community. These groups determine their own goals, manage their own houses and business affairs with the assistance of the Office of Residential Services and the FMA, conduct their own social, philanthropic, and athletic activities, plan 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-nine fraternities and eight sororities form a larger Greek community comprising approximately 45 percent of the undergraduate population at Lehigh. Through the Interfraternity Council (I.F.C.) and Panhellenic, 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 South Mountain Campus, one in Parks Lake House and one in Overlook House located in Sayre Park. The sororities are Alpha Chi Omega, Alpha Gamma Delta, Alpha Omicron Pi, Alpha Phi, Delta Gamma, Delta Zeta, Gamma Phi Beta, Kappa Alpha Theta. 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, Pi Lambda Phi, Psi Upsilon, Sigma Alpha Mu, Sigma Chi, Sigma Nu, Sigma Phi, Sigma Phi Epsilon, Theta Chi, Theta Xi, and Zeta Psi.

The University Forum

The Lehigh University Forum is a unique deliberative body whose purpose is to promote the welfare of the university and attainment of a true sense of community by bringing into discourse students, faculty, and administration.

A restructuring process, completed in 1988, resulted in a simplified Forum committee structure as well as the creation of a Student Senate which deals with issues pertaining solely to students.

Its membership includes elected representatives of the student body and of the faculty, and members of the administration (including the president, provost, vice president for student affairs and dean of students).

Five Forum representatives—three students and two faculty members—attend meetings of the board of trustees. Free to inquire into any aspect of university operations, the
Forums afford faculty and students a voice in university affairs equal to few institutions.

The Forum appoints student members to certain standing committees of the faculty and certain ad-hoc university committees when invited.

All meetings of the Forum are open to the university community, with the right to address the Forum provided to any person desiring to do so.

The Forum office is located in Packer Hall, the university center, and students are invited to come in to discuss any aspect of university government.

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, a Community Service Desk that helps coordinate volunteer services on campus, a Chaplain’s Forum, and a “Films for Discussion Series”. 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 Hillel Society, which sponsors various activities for Jewish students under the leadership of a rabbinic seminarian; and organizations for Hindu and Muslim 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.

Lehigh University Theatre

The department of theatre produces four plays yearly in its mainstage subscription series, presented at Wilbur Drama Workshop. The plays range from the classics to world premieres, and in recent seasons have included The Wild Duck, Josephine: The Mouse Singer, The Servant of Two Masters, A Delicate Balance, Endgame, Rashomon, As You Like It, and On the Verge.

Auditions are open to all members of the university community. All interested students are welcome to participate on production crews such as set construction, properties, lighting, sound, and wardrobe. Advanced students have opportunities to direct or design, under faculty supervision.

The Lab Theatre in Coppee Hall hosts shows directed and produced by students as class projects or independent work. Recent Lab Theatre productions have included The Lesson, The Long Goodbye, The Bear, Hopscotch, The Shawl, This Property Is Condemned, The Fallen Angel, Penguin Blues, and Terminal Bar.

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 — regularly 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 the Touchstone Theatre Ensemble, playwrights Russell Davis and Wendy Wasserstein, Second Hand Dance Company, stage manager Colleen Davis, ’91, and Irondale Ensemble.

In spring 1994, the department will co-sponsor, along with the Office of Cultural Affairs and Touchstone Theatre, “Theatre of Creation,” an international festival celebrating the work of renowned movement theatre pioneer Jacques Lecoq. The festival drew hundreds of performers, students, and teachers from around the world, including M. Lecoq, who was on campus to teach a week long master course.

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, camera, computer, languages, rugby, sailing, skiing, boxing, judo, crew, political clubs, fencing, and waterpolo. 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.
Musical Organizations

The university sponsors both a variety of student musical organizations that give performances on and off campus and a professional concert series. Music at Lehigh, that brings visiting artists to the campus. The choirs, bands, orchestra, and ensembles are conducted by members of the faculty and managed by elected student leaders.

Christmas Vespers and Spring Vespers are traditional choral performances. The university choir has toured Canada, Puerto Rico, the Virgin Islands, Washington, D.C., California, and throughout Pennsylvania.

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 Wind Ensemble plays a winter concert and a pops concert on campus during the spring and takes an annual tour (Florida, Montreal, New Orleans, Boston, Bermuda, etc.). The Concert Band performs a joint concert with the Wind Ensemble in the winter and a final concert in the spring. The Concert Band is open to students, faculty, and staff as well as members of the community.

The Jazz Ensemble plays concerts on campus, at festivals, and on the joint Wind Ensemble tour in the spring. The Jazz Band performs jointly with the Jazz Ensemble and on the final Concert Band concert.

Performances by the string orchestra and the ensembles traditionally close the semester concert season. The ensembles include groups of string, brass, woodwind, percussion and mixed instruments.

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 annually brings a composer of national reputation to campus in order to discuss and play his/her music.

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. Pregame and half-time performances are precision drills with a varied repertoire from classical music to traditional fight songs. Nine students serve in executive positions.

The concert series Music at Lehigh presents a variety of concerts and recitals. Among the artists who have appeared are the Orpheus Chamber Orchestra; Lark String Quartet and Dawn Upshaw, Met soprano. Inaugurated in 1980, the Ralph Van Alen Chamber Music Series presents concerts of outstanding chamber music; the series honors the memory of a Lehigh faculty member.

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.

Volunteer Services

A wide variety of volunteer activities are available at Lehigh through living groups, student clubs or organizations or special projects such as Community Interaction Day and Benefit for the Homeless. Typically, well over 1000 students a year participate in volunteer service efforts in the Lehigh Valley area in a range of service programs.

Most of the volunteer work is done in cooperation with local community agencies. Some of the projects include tutorial programs in public and private schools, work in local hospitals, fund raisers for national charities or affiliation with groups such as Habitat for Humanity, Big Brothers/Big Sisters and New Bethany Ministries.

Organizations as well as individuals looking to help their community can consult the Community Service Desk at 758-4583 coordinated by the University Chaplain in Johnson Hall, 758-3877. Volunteer opportunities are also posted on Lehigh’s campus-wide computer network system.

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 attorney F. Lee Bailey, Lee Iacocca, philosopher Derek Parfit, actor Vincent Price, 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, and women's volleyball and tennis.

WINTER: Men's and women's basketball, wrestling, men's and women's indoor track and swimming.

SPRING: Baseball, tennis, golf, men's and women's outdoor track, and lacrosse and women's softball.

Athletic facilities are located in Taylor Gymnasium and Grace Hall and on the Murray H. Goodman campus, which is located two miles south of the main campus. The 500-acre Goodman athletic complex includes the Stabler Athletic and Convocation Center, which seats 6,000 and hosts most of Lehigh’s wrestling matches and basketball games. The campus also contains the Philip Rauch Field House, which includes a one-eighth-mile track and indoor tennis and basketball courts. Goodman Stadium, a 16,000 seat stadium for football, soccer and lacrosse was added in 1988. Other facilities on the campus include a championship cross-country course, baseball and softball fields, indoor squash courts, tennis courts, lacrosse and field hockey fields, and an all-weather, nine-lane, outdoor 400-meter track. A new indoor tennis center opened in the spring of 1994.

Lehigh is affiliated with the National Collegiate Athletic Association (NCAA), the Patriot League and the Eastern College Athletic Conference (ECAC). Lehigh frequently hosts championship events in men’s and women’s sports.
Intramural Sports
The department of intramural sports supervises some 30 intramural sports. The aim is to insure the health and physical development of students.

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.

On a club-level, there are from 28 common-interest groups ranging from outing and equestrian to frisbee and floor hockey. Several club level teams compete with other colleges on a regular basis (crew, rugby, ice hockey, bowling, volleyball, 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 the society of which the university is a part.

Furthermore, society generally provides legal canons, ethical mores, and conduct expectancies pertaining to individual and collective behavior. Thus, the university has the obligation 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 that responsibility. Specific regulations are kept to a reasonable minimum and are published in the Lehigh Student Handbook. Students are responsible for knowing the procedures, rules and regulations 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.

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.
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, university's 1,600 acres comprising its three Bethlehem classes are a special resource, providing a beautiful environment for learning. Following are descriptions of various resources related to academic programs.

**Collections and Computers**

The directness of the printed word, the vision of art, and the power of computers all play important roles in a broad, liberal education. University collections and facilities place a wealth of information at the student's disposal.

**Libraries**

The Lehigh Library system serves as the information hub of the University, as well as an essential element in the educational process, providing access to electronic and traditional resources, including extensive book, journal, microform, software, and media collections. In 1992 the Libraries celebrated the acquisition of its one millionth volume and the 125th anniversary of the Library system, along with continuing transformation from the paper library to an electronic information center.

Using the concept of LiberSpace ("the wide open library"), any user may access not only local databases, such as the online catalog, ASA, but also a wide spectrum of remote databases from every residence hall, faculty office, classroom, and laboratory. Included in the array of remote databases are the tables of contents from over 11,000 journals; several hundred international electronic databases; full text services such as Lexis/Nexis; and systematic access to Internet gopher and web sites. Visit the libraries' home page at http://www.lib.lehigh.edu. All library services are available electronically through the campus-wide network: these include requesting reference assistance; obtaining documents as photocopies or through interlibrary loan; requesting media services; requesting circulation recalls and reserves, etc. A CD-ROM LAN, with a wide range of subject databases, may be accessed through remote login from other public sites on campus.

**Facilities and Collections**

With the opening in 1985 of the E.W. Fairchild-Martindale Library and Computing Center, adjoining the Mart Science and Engineering Library, the combined information center merged more than 500,000 volumes in the social sciences with a 200,000-volume collection in the natural and physical sciences, mathematics, and all branches of engineering. The facility also houses government documents and business collections.

The historic Linderman Library, part of which was built in 1877, is dedicated to all branches of the humanities. A collection of 400,000 volumes encompasses strengths in British colonial history, and American and English literature. The Bayer Galleria of Rare Books, which opened in 1985, embraces the university libraries' Special Collections Division, estimated to include about 24,000 volumes. Included here are the extensive rare-book collections, many of which were donated by the libraries' benefactor, Robert B. Honeyman, as well as university archives, and Congressional papers. Noteworthy among the treasures in the rare book collection are an original edition of John James Audubon's *Birds of America* and three copies of the first edition of Charles Darwin's *Origin of Species*.

The Chrysler Library on the Mountaintop Campus serves as an electronic access point for the convenience of the academic departments located there.

**Resources**

Library holdings represent a rich resource for the university community. In addition to the collection of over 1,000,000 volumes, the libraries receive more than 10,000 periodicals and serials, including a well-developed foreign and domestic newspaper collection. Another important research tool is the government documents collection. A partial government depository since the 19th Century, the libraries hold more than
550,000 federal, Pennsylvania, and United Nations documents, as well as a vast collection of technical reports from governmental agencies.

Nonprint collections of nearly 1,900,000 microforms and 30,000 audiovisual resources enhance the traditional book and journal collections. The David M. Greene music collection includes several thousand tapes and cassettes of classical music. The libraries also have a wide range of reference sources in all fields on compact disk. These CD-ROM databases offer yet another alternative for the retrieval of current literature.

University library resources are augmented by memberships in the Lehigh Valley Association of Independent Colleges; PALINET, Pennsylvania Area Library network; IDS, Interlibrary Delivery Service of Pennsylvania; OCLC, Online Computer Library Center; as well as the International Association of Technological University Libraries.

Services
The university library staff, numbering 59 full-time and part-time employees, serves the needs of faculty and students by providing programs that stimulate the use of the information system as a vibrant intellectual resource. Helpful personal assistance is available from staff in such areas as navigating networks for remote data bases, instruction in bibliographic research, library orientation, current-awareness services, and interlibrary document retrieval.

The advent of the campuswide network and the ease of accessing electronic information has enabled the library to supply all users with electronic as well as traditional services. Users can order material—including photocopies and interlibrary loans—and submit electronic reference inquiries and obtain media services via the network 24 hours a day. The reference staff has been providing a major instructional effort for end-user searching of both local and remote data bases.

As a convenience to the university community, the libraries have available microcomputers and workstations, photocopiers, and laser printers.

As a service to the extended community of alumni and regional corporations, the libraries sponsor a fee-based information service for business, industry, and government. A Friends of the Libraries program has also been in existence since 1981. The Friends programs provide another vehicle for university cultural activities in the form of lectures, concerts, and exhibits.

Media Center
University Instructional Media Services include three service areas. The Fairchild-Martindale Media Center provides opportunities for individual and group listening and viewing of audio and video tapes, cassettes, records, slides and films, in a collection numbering more than 25,000 units. In addition, selected computer software is available for loan or use by the university community. The center includes an electronic classroom; a public access site for individual and small group listening and viewing; and microcomputers for general-purpose use.

Media production services, located in Linderman Library, offers a full spectrum of activities, including video and audio production, photographic services, slide preparation, graphics, and computer-generated graphics. Consulting is also available for preparation and handling of equipment.

Special audiovisual services prepare identification cards, handle the equipment needs for public affairs, and serve selected instructional needs for equipment.

Networking
This fall, students occupying University housing will arrive on campus to find telephone and high-speed network connections available in each room. As described below, the telephone connection to the InteCom digital PBX provides the students in each room with the capability of simultaneous voice and data transmission, at no additional charge. Optional high-speed network connections are available to each individual student, for a fee, on a per-semester basis, as part of the WIRED (World-Wide Information Resources in Every Dorm) project. WIRED provides direct, high speed access to the global information resources available via the Internet – at data rates sufficient to take advantage of graphically-oriented services such as browsing the World-Wide Web with Mosaic or Netscape. WIRED also provides access to shared local printers and shared applications programs, such as WordPerfect for Windows.

Lehigh's campus telephone network, the InteCom PBX, permits simultaneous voice and data exchanges which enable students and faculty in 150 campus buildings to converse o n the phone while exchanging information on their computers. On campus, each student's room has been equipped with one connection ("port") to the digital PBX which handles both voice and data communications. One telephone and one data unit per room are provided to connect into that port. To access computing facilities by phone, the student needs only to connect his or her microcomputer to the data unit, and install the appropriate communications software (available from the Computing Center). There is also one high-speed network "port" per person in each room, which can be activated if the student elects to participate in the WIRED project. Keep in mind that students are not required to purchase computers! Approximately 440 microcomputers and UNIX workstations have been installed at 30 public computing sites around campus. Laser printers have been placed at strategic locations as well.

Networking at Lehigh extends beyond the InteCom digital PBX described above and includes Local Area Networks (LANs), which connect computers such as those at public computer sites, most departmental offices, and the WIRED project residences; a high-speed "backbone" network, which connects the various LANs via fiber-optic cable; and a connection between our campus networks and the state-wide PREPnet network, which is part of the Internet. These connections provide access both to Lehigh's own local computing resources as well as to the global services offered by the Internet. Local resources include: centralized Compute Servers; a campus-wide information system known as LUNA.
on a cluster of systems known collectively as the Network Server; a complete library information and catalog system; and numerous high-performance UNIX workstations. Internet resources include: electronic mail; access to computing and file archive sites via Telnet and FTP; menu-based information via Gopher; and, multimedia information via the World-Wide Web.

Qualified Lehigh computer users may also apply for access to the resources of the Pittsburgh Supercomputing Center (PSC), which houses and operates a Cray Y-MP C90 parallel vector-processor and a Cray T3D massively parallel processor. Users granted accounts at the PSC can access these supercomputers via PREPnet.

All Lehigh students, faculty, and staff are eligible to purchase microcomputers and UNIX workstations at the university's Computer Store. Those who are considering acquiring a computer of a type not available from the store should consult a member of the Computing Center staff to insure compatibility with the university's communications networks.

Professors and staff at Lehigh use their computers to communicate more easily with students and among themselves, to develop teaching software, and to improve research. Lehigh officials believe that networking facilities add a new dimension to education at Lehigh, as students and faculty find more uses for them, our networks are constantly evolving, with potential advantages that even the most forward-looking cannot visualize completely.

Computing Center

The Lehigh University Computing Center (LUCC) provides computing services to all university departments and research centers, serving the existing needs of students, instructors, researchers, and administrative users while anticipating and preparing for the future requirements of its user community. The central computing facility, which is located in the E. W. Fairchild-Martindale Library and Computing Center (Building 8-B), houses a network of International Business Machines (IBM) RISC System 6000 (RS/6000) high-performance computers, configured as centralized Network Servers, Compute Servers, and File Servers. A cluster of five high-performance IBM RS/6000 computers (called the Network Server Cluster) provides campus communications services such as electronic mail, campus-wide electronic bulletin boards, and access to world-wide electronic news groups such as USENET. A cluster of two high-performance IBM RS/6000 computers (called the Compute Server Cluster) provides compute services for compute-intensive applications, including a variety of programming languages, mathematical and statistical software packages, and graphics packages. The Network Server Cluster and Compute Server Cluster are used primarily for instruction and research. In addition, the Computing Center houses, maintains, and operates an IBM 4381 Model 14 mainframe computer and several dedicated IBM RS/6000 computers which are used exclusively for administrative processing.

Centralized high-speed printing services are provided by three QMS-1700 PostScript laser printers. Centralized plotting services are provided by two Hewlett-Packard multi-pen, publication-quality plotters. Distributed printing services are provided by a network of PostScript laser printers located at 15 remote workstation sites around the campus. Local printing services are also provided by Hewlett-Packard LaserJet printers at numerous public microcomputing sites.

In addition to the centralized facilities described above, LUCC maintains a total of 40 public computing sites, computer classrooms, and computer-equipped lecture rooms across the campus. LUCC operates 22 fully-equipped computer classrooms, suitable for "hands-on" computer instruction; each computer classroom has either IBM-compatible PCs, IBM PS/2's, or IBM RS/6000 workstations which are interconnected via a Local Area Network (LAN), and a large-screen projection system which is connected to the instructor's station. For example, LUCC operates and maintains a testing lab for the Department of English and a multimedia lab for the Department of Modern Foreign Languages and Literature; both of these facilities are an integral part of the curriculum. In addition to these computer classrooms, LUCC maintains 10 lecture rooms suitable for computer-based demonstrations; each of these lecture rooms is equipped with a computer connected to either a large-screen projection system or to large display-monitors located throughout the room.

Approximately 310 microcomputers (primarily IBM-compatible PCs) are available for use at the public computing sites. The microcomputers at public sites are connected via Local Area Networks (LANs) running Novell NetWare. Software packages available for the microcomputers at public LAN sites include word processing programs such as WordPerfect, WordStar, and EXP, spreadsheet programs such as Quattro Pro and Lotus 1-2-3; database management systems such as dBASE and Paradox; mathematical and statistical applications such as Maple, MatheCAD, SAS, and STATGRAPHICS; scientific and presentation graphics packages such as GNUPLOT and WordPerfect Presentations; terminal emulation programs such as MS-Kermit; and high-level programming languages such as PASCAL, C, C++, FORTRAN, BASIC, and PROLOG.

In addition to the microcomputers at public sites, LUCC maintains over 120 IBM RS/6000 workstations distributed at public computing sites across the campus. The RS/6000 workstations run an IBM version of the UNIX operating system (called AIX) with an X-Windows/Motif graphical user interface. These distributed RS/6000 workstations are connected via the campus backbone network to the centralized AFS File Servers, which enable each user to access all of his or her files from any AFS workstation. Software available for use on the RS/6000 workstations includes a variety of mathematical, statistical, graphics, and document-preparation packages, such as Maple, Matlab, the IMSL FORTRAN Library, GNUPLOT, and TeX/LaTeX, as well as programming languages such as FORTRAN, C, C++, PASCAL, and LISP.

In addition to the RS/6000 workstations at public sites, the Computing Center manages the Computer-Aided Design (CAD) Laboratory for the Department of Mechanical
Engineering and Mechanics. The CAD Lab is equipped with both IBM RS/6000 and Hewlett-Packard workstations, and runs industry-standard CAD applications such as Unigraphics II, SDRC Ideas, and ADAMS.

All of the LUCC centralized Network Servers and Compute Servers, as well as the distributed IBM RS/6000 workstations at public sites, can be accessed remotely from on campus via the campus backbone network, or from off campus via dial-up phone lines. In addition, all microcomputers and RS/6000 workstations at public sites can connect to the centralized machines via the campus high-speed backbone network. (See the section on Networking for details.)

**Educational Opportunities**

Seminars on various topics pertaining to computing are held or sponsored by LUCC for faculty, staff, and students; many of these seminars provide an opportunity for guided, "hands-on" experience with various computing platforms and software packages in one of LUCC's computer classrooms. Student accounts are available on all LUCC computing systems. Qualified undergraduates and graduate students may further improve their computing knowledge and proficiency by working part-time in one of the following LUCC service groups: User Services, Systems Programming, Operations, or the Computer Store.

LUCC has prepared a description of its computing facilities and services, *A Guide for Users of the Lehigh University Computing Center*. This literature can be obtained free of charge by writing to User Services, Fairchild-Martindale Computing Center, 8-B East Packer Avenue, Lehigh University, Bethlehem, Pennsylvania 18015, or by calling (610) 758-3990.

**Policies on the Use of Computer Systems and Facilities**

The following policy contains the governing philosophy for regulating the use of Lehigh University's computing facilities and resources. Access to the University's computing facilities and resources is a privilege granted solely to Lehigh faculty, staff, and registered students. Exceptions apply to those individuals outside the University who pay to use computer applications which are unavailable locally and to those individuals outside the University who utilize services that have been made publicly available through Lehigh. All users of the computing facilities must act responsibly and maintain the integrity of these resources. The University reserves the right to limit, restrict or extend computing privileges and access to its resources. Those who do not abide by the policies listed below should expect at least suspension of computer privileges and possible referral to the University Committee on Discipline.

Offenders may also be subject to criminal prosecution under federal or state law, and should expect the Computing Center to pursue such action. As an example, under Pennsylvania law, it is a felony punishable by a fine of up to $15,000 and imprisonment up to seven years for any person to access, alter or damage any computer system, network, software or database, or any part thereof, with the intent to interrupt the normal functioning of an organization (18 Pa.C.S. 3933(a)(1)). Disclosing a password to a computer system, network, etc., knowingly and without authorization, is a misdemeanor punishable by a fine of up to $10,000 and imprisonment of up to five years, as is intentional and unauthorized access to a computer, interference with the operation of a computer or network, or alteration of computer software (18 Pa.C.S. 3933(a)(2) and (3)).

The Computing Center should be notified about violations of computer laws and policies, as well as about potential loopholes in the security of its computer systems and networks. The user community is expected to cooperate with the Computing Center in its operation of computer systems and networks as well as in the investigation of misuse or abuse. Should the security of a computer system be threatened, user files may be examined under the direction of the Computing Center Director.

**Policies**

The Computing Center's policies include, but are not limited to, the list below.

1. You must not use a computer ID that was not assigned to you by LUCC, unless multiple access has been authorized for the ID by LUCC. You must not try in any way to obtain a password for another's computer ID. You may not attempt to disguise the identity of the account or machine you are using.

2. You must not use the Computing Center's network resources to gain or attempt to gain unauthorized access to remote computers.

3. You must not deliberately perform an act which will seriously impact the operation of computers, terminals, peripherals, or networks. This includes, but is not limited to, tampering with components of a local area network (LAN) or the high-speed backbone network, otherwise blocking communication lines, or interfering with the operational readiness of a computer.

4. You must not attempt to modify in any way a program diskette which the Computing Center supplies for any type of use at its sites.

5. You must not run or install on any of the Center's computer systems, or give to another, a program which could result in the eventual damage to a file or computer system and/or the reproduction of itself. This is directed towards, but not limited to, the classes of programs known as computer viruses, Trojan horses, and worms.

6. You must not attempt to circumvent data protection schemes or uncover security loopholes.

7. You must abide by the terms of all software licensing agreements and copyright laws. In particular, you must not make copies of copyrighted software, unless the Computing Center has a site license specifically allowing the copying of that software. Furthermore, you must not copy site-licensed software for distribution to persons other than Lehigh faculty, staff, and students, nor may you copy site-licensed software for use at locations not covered under the terms of the license agreement.
8. You must not deliberately perform acts which are wasteful of computing resources or which unfairly monopolize resources to the exclusion of others. These acts include, but are not limited to, sending mass mailings or chain letters, creating unnecessary multiple jobs or processes, obtaining unnecessary output, or printing or creating unnecessary network traffic. Printing multiple copies of any documents including resumes, thesis, and dissertations is also prohibited.

9. The following type of information or software cannot be placed on any university-owned computer system:
   - That which infringes upon the rights of another person.
   - That which is abusive, profane, or sexually offensive to the average person.
   - That which consists of information which may injure someone else and/or lead to a lawsuit or criminal charges. Examples of these are: pirated software, destructive software, pornographic materials, or libelous statements.
   - That which consists of any advertisements for commercial enterprises.

10. You must not harass others by sending annoying, threatening, libelous, or sexually, racially, or religiously offensive messages.

11. You must not attempt to monitor another user's data communications, nor may you read, copy, change, or delete another user's files or software, without permission of the owner.

12. You must not use any of the Center's microcomputers, workstations, or networks for other than a Lehigh University course, research project, departmental activity, or personal communications. These resources must not be used for personal or financial gain unless a Personal, External Educational, or Industrial account (which are all billable) is used.

13. You must not play games using any of the Center's computers or networks, unless for instructional purposes as specifically assigned by a professor.

14. Any network traffic exiting the University is subject to the acceptable use policies of the network through which it flows (PREPnet, NSFNET, etc.), as well as to the policies listed here. In general, commercial use of external networks is prohibited. Copies of acceptable use policies for a number of networks are available from the Computing Center.

The above policies supplement the University Code of Conduct, which covers such acts as theft of computer services (including copyrighted computer programs), theft or mutilation of Lehigh property such as equipment, and the unacknowledged or unauthorized appropriation of another's computer program, or the results of that program, in whole or in part, for a computer-related exercise or assignment.

Software developers should refer to the "Procedure on Software Disclosure and Development" regarding title rights; this procedure can be found in Appendix A-10 of the "Lehigh Research Manual". In general, the University has the title rights to software developed under a University account (see Addendum). This may also apply to Personal and External Educational accounts where the computer usage is related to University-funded activities.

**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 five 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 art galleries occupy exhibition, storage, office and workshop space in several campus locations. The Ralph L. Wilson and Hall galleries are located in the Alumni Memorial Building; Maginnes Hall houses the DuBois Gallery; The Siegel Gallery is in Iacocca Hall, Mountaintop Campus. Administrative offices and workshop are in Chandler-Ullmann Hall. The Muriel and Philip Berman Sculpture Gardens are located in the courtyard of Mudd, Mart, Whitaker and Sinclair Buildings; on the Mountaintop Campus and Saucon Field, Murray H. Goodman Campus. The Study Gallery and Open Storage facility is in Building J, mountaintop campus, available by appointment.

**Exhibitions**

Exhibitions and gallery events are planned 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, Hobbs, Hoppe, and others); the Dreyfus Collection of French Paintings (Bonnard, Sisley, Vuillard, Courbet); the Ralph L. Wilson Collection of American Art (paintings by Prendergast, Sloan, Henri, Lawson, Bellow, Davies, Burchfield; prints by Whistler, Hassam, Motherwell, Johns, Rauschenberg, Calder, Warhol); the Prasse Collection of Prints (Delacroix, Tissot, Renoir, Kent, Kunyoshi, Rivera); the Philip and Muriel Berman Collection of Contemporary Sculpture (Kadishman, Unger, Tumarkin, Bertoia, Shaw).

Also, the Farnsfield Collection of European Old Master Prints and Drawings; the Baker Collection of Chinese Porcelains; the Langemann Collection of Pre-Columbian Sculpture; 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, Strand, Siskind, Hahn, Clark, Martinez-Canas, Serrano); and the Lehigh University Contemporary Prints Collection (Bearden, Rivers, Anusziewicz, Soto, Roth, Chryssa, Ruscha, Tobey, Calder, Kitaj, Marca-Relli, Genoves, Cruz Azaceta, Golub, Jimenez, Piper, Serrano, Simpson), and the Philatelic and Numismatic collection.

Lehigh University Press

Lehigh University Press represents a clear expression of faculty and institutional commitment to the advancement of scholarship. Philip A. Metzger, Associate Director for Preservation and 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 studies; and 18th 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 six live-in professional hall directors, 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 Student Life 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.

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

If a student is uncertain about or needs to know more about his or her own capacities, interests, or personal characteristics, the university counseling service as well as testing services are available without charge. Confidential interviews may be arranged by any student who wishes to review his or her own
The Office of Alcohol and Other Drug Programs is located on student's life. Through our educational programs we staff members (a wellness coordinator and an alcohol and smaller institution. Services are available for all student students and student life. They serve as academic advisers , assist a student with AOD problems to get the help they need. a Peer Education Program.

and/or family having problems with substance use. find themselves having problems because of or with their encourage students to adopt healthy lifestyles and avoid high risk behavior. They are encouraged to seek assistance if they find themselves having problems because of or with their substance use (alcohol and/or drugs), or if they have friends and/or family having problems with substance use.

Prevention services include the implementation of theme weeks (Alcohol & Drug Awareness Week and Wellness Week), educational programs for living groups on a variety of Alcohol & Other Drug (AOD) topics, and the development of a Peer Education Program.

Intervention services include training programs for Residence Life staff, Peer Educator Groups, and other members of the Lehigh community. The purpose of the training is to develop a broad safety net of interveners that can assist a student with AOD problems to get the help they need.

Another service is intervention counseling for people who are concerned about another's AOD use and want to do a "caring confrontation" with that person. This is often a very successful way of convincing a person with an AOD problem to seek help.

Individual and group therapy sessions are provided by the A.O.D. counselor community center. On campus counseling enables many students to successfully enter into recovery (from alcoholism or chemical dependency) or to significantly alter a previously self-destructive lifestyle without having to disrupt their university career. If a student cannot accomplish this on campus, then referrals to in-patient treatment programs can be made. Aftercare services can be provided once the student returns to campus.

Lehigh University has a growing group of recovering students that maintain a Alcoholics Anonymous (A.A.) meeting on campus. There are also a number of A.A. and N.A. meetings in the surrounding community that students can attend.

Any contact with the staff of the Office of Alcohol and Other Drug Programs is held in the strictest confidence. Contact with the staff members may last from one session to several sessions.

Appointments are easy to make by calling the Office of Alcohol and Other Drug Programs at 758-5359 or by stopping at the office during office hours (8:30 a.m. to 4:45 p.m.), Monday through Friday.

Drug and Alcohol Program
The Office of Alcohol and Other Drug Programs is located on the fourth floor of Johnson Hall in room 419. Services are offered free of charge for a wide range of issues revolving around substance use, misuse, abuse and dependency. Two staff members (a wellness coordinator and an alcohol and other drug counselor) provide services that span prevention, intervention, treatment and aftercare. Lehigh University recognizes that substance abuse and chemical dependency are issues that touch many families and can deeply affect a student's life. Through our educational programs we encourage students to adopt healthy lifestyles and avoid high risk behavior. They are encouraged to seek assistance if they find themselves having problems because of or with their substance use (alcohol and/or drugs), or if they have friends and/or family having problems with substance use.

Prevention services include the implementation of theme weeks (Alcohol & Drug Awareness Week and Wellness Week), educational programs for living groups on a variety of Alcohol & Other Drug (AOD) topics, and the development of a Peer Education Program.

Intervention services include training programs for Residence Life staff, Peer Educator Groups, and other members of the Lehigh community. The purpose of the training is to develop a broad safety net of interveners that can assist a student with AOD problems to get the help they need.

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.

In these and in other ways Lehigh University endeavors to maintain the close contacts with students that characterize the smaller institution. Services are available for all student concerns, and the student need only turn to his or her nearest residence hall counselor, professor, or the Lehigh Handbook to learn where help can be obtained.

Health Center
The university offers health services to all students at the Health Center in Johnson Hall. During the fall and spring semesters, doctors are available to see patients, 9:00 a.m. to 5:00 p.m. Monday to Friday, and 10:00 a.m. to noon Saturday. A registered nurse is present to see patients after hours with a physician available on call 8:00 a.m. to 6:00 p.m. Monday through Friday, 10:00 a.m. to 6:00 p.m. Saturday and 12 noon to 6:00 p.m. Sunday. During breaks, hours are Monday to Friday 9:00 a.m. to noon and 1:00 p.m. to 4:30 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 to 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 relatively low-cost university-sponsored insurance plan is available. Expenses covered include costs for several 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.

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 program of the health service.

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 (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 therapies, faculty and staff consultation, and numerous outreach activities are some of the primary means by which the mission is accomplished. UCS staff is 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 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 provides group and individual counseling and psychotherapy services to both undergraduate and graduate students. A brief treatment model is used for individual work while much of the group work is of longer duration. On-site psychiatric consultation is available with staff referral. 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 may occur in various settings including residential settings, classrooms, athletic sites, and meeting rooms across the university. Topics may include issues related to race, eating, sexuality, drinking and other drug use, study styles, athletic performance, grieving, stress, culture and relationships. Much of this programming is done in partnership with T.A.L.Q., the UCS student peer group supervised by UCS professional staff.

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

* Consultation Services
The staff provides 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 and identity and skills within the role of a psychologist - these typically being graduate 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 Learning Center
Success at Lehigh depends in part on mastery of a number of advanced academic skills. Such skills are needed to study effectively (prepare assignments, take notes, outline, listen, recall information), to take examinations, to write well, to understand advanced mathematical concepts, and to keep up with a great deal of critical and comprehensive reading.

At Lehigh, a campus noted for its highly motivated student body and strenuous academic program, 15 percent of undergraduates, including a third of full-time freshmen, use the tutorial services of The Learning Center. Established in 1977, it provides a schedule of workshops, review sessions, and most importantly, individual tutorials in study skills, mathematics, reading and writing. Through a program of faculty and student referrals, along with periodic notices to the student body, the center helps students to improve specific communication and mathematical skills, to maintain acceptable performance levels, and to raise their academic standing. Individualized assistance is emphasized.

The Learning Center provides university students with a continuing opportunity for academic improvement through personalized instruction by professors and graduate teaching assistants. The center is located in Drown Hall.

The Computer Store
The Lehigh University Computer Store offers microcomputers (including models from IBM, Zenith, and Apple), printers, software and accessories to Lehigh students, faculty and staff at reduced educational prices. The LUCS provides hardware maintenance service for systems purchased at Lehigh. The store is located at 524 Brodhead Ave. and is open weekdays from 9:00 a.m. to 5:00 p.m. Information regarding prices, special offers and other related details can be obtained through the campus network or by calling (610) 758-4606. Mastercard and Visa are accepted.

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. Because developing one's career potential is an integral part of this process, Lehigh provides career planning and placement services for its 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 writing effective resumes and cover letters, 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, and 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 offers the following resources and services to help students prepare for professional opportunities after graduation:

Career resources. Among the resources available in the Career Services Information Center 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, and a video-tape library covering a wide range of career-related subjects, job listings for part-time, summer, internship, entry-level and experienced opportunities, "user-friendly" national employment databases, an electronic bulletin board with postings and Federal Government information, and a directory of alumni contacts who have volunteered to assist students with their job-search strategies.

Pre-professional advising. The pre-professional advisor, along with a faculty advisory committee, provides information and guidance to candidates pursuing careers in medicine, dentistry, and other health professions, including individualized advising, special programs on health-related topics and field trips. In addition, information and assistance is provided for students interested in law school and legal careers.

Career programs and workshops. 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 Graduate School Fair and the Career Fair and many others are offered throughout the year. Workshops on resume writing, interviewing techniques, and job-search strategies are also offered.

Summer and part-time jobs. Summer and part-time job listings and internship opportunities are available through Career Services for all students interested in gaining short-term, career-related experience. This is part of a student employment program designed to offer "hands-on" career experience and financial assistance.

Individual consultation. Students may meet with members of the staff to discuss their career options and goals, individual job-search strategies, effective interviewing, and related interests.

Placement Manual. This manual helps students learn how to use the on-campus interviewing system, prepare for interviews and plant/office visits, write resumes and letters, and develop individual strategies.
On-campus interviewing. Staff members work with approximately 500 business, industrial, and government representatives who interview on campus each year. Seniors and graduate students typically take a total of about 6,000 interviews.

The office, located in Christmas-Saucon Hall, is open throughout the year.

Continuing Education, Distance Education, and Summer Studies

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.

Distance Education:

The distance education program at Lehigh provides educational opportunities to adults at their work sites. The program strives to maintain the same level of quality that is available to on-campus students. The distance education staff views distance students and their employers as clients of the University, deserving of the best possible effort in all areas of the operation. All programming is delivered over the Lehigh Educational Satellite Network (LESN), which employs a Ku-Band earth station capable of reaching all domestic satellites in either digital or analog mode. At present, the University offers master's degrees by satellite in Chemistry, Chemical Engineering, Quality Engineering, and the MBA. Also available is a certification/degree program in Principalship and Superintendency sponsored by the Lehigh College of Education. In addition to its own degree programs, Lehigh provides courses to National Technological University master's programs, and a range of non-credit short courses and seminars. For more information, call the Distance Education Office at (610) 758-5794.

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, Latin America, 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.

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.
III.

Undergraduate Studies

Graduation Requirements
Students are expected to maintain regular progress toward the baccalaureate degree by carrying the "normal" course load—between twelve and eighteen 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 ninety credit hours in residence, or all of the last thirty 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 Science must have a minimum of thirty additional credit hours beyond the first degree credit-hour requirements in order to qualify for the second degree. All of the thirty 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.

This adviser is one of the most valuable resources in the educational process, not only to assist in making academic selections to match the student's particular background, interests, and future objectives, but also to identify program options, to work out an academic pace, and to develop career planning strategies. The adviser will help to identify other resources and support systems available at the university, such as The Learning Center, the counseling service, and the office of career services.
Guide to Academic Rules and Regulations

The university, like the rest of society, has adopted over the years numerous rules and regulations. Some of the principal rules and regulations are given here so that currently enrolled and potential undergraduates and graduate students will be apprised of what is expected of them, and what they can expect of the university.

This section concerns academic regulations. Additional regulations can be found in the Lehigh Handbook, and there is a comprehensive statement of all policy in the publication Rules and Procedures of the Faculty. All students are given a Handbook at the beginning of the fall semester; Rules and Procedures is available in the university libraries and in departmental and administrative offices.

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 chairpersons are available to assist the student. It is strongly recommended that the students 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 requested 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 December 1; candidates for graduation on Founder’s Day, the second Sunday in October, file a notice of candidacy on or before September 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 need 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+ and C, competent; C-, continuation competency (the student has achieved the level of proficiency needed for the course to satisfy prerequisite requirements); D+, D, and D-, passing, but performance is not adequate to take any subsequent course which has the 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 instructor of the course, the teaching department chairperson and the chairperson 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; WF, 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-, P, and Cr may be credited toward baccalaureate degrees within the limits of program requirements. Grades of F, N, X, XN, W, WP, and WF cannot be credited toward the degree. Grades of W and WP do not count as hours attempted.

Courses in which grades of 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 writing at the beginning of the course of a substitute method for determining the parenthetical grade.

In each case in which an N grade is given, the course instructor shall provide written notification to the department chairperson stating the name of the student receiving the grade, the reason for the incomplete work, the work to be done for the removal of the N grade and the grade for the work already completed.

A student who incurs an N grade in any course is required to complete the work for the course by the fifth day of instruction in the next regular semester. The N grade will be converted into the parenthetical grade after the tenth day of instruction in the next regular semester following receipt of the N grade unless the instructor has previously changed the grade using the removal-of-incomplete procedure. The parenthetical grade will be dropped from the transcript after the assignment of the course grade.

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 parenthesis 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 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's 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 incompletion 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.

Where failure to complete coursework prevents the student from taking the make-up examination at the scheduled time, the student may petition the committee on standing of students for a later examination.

An XN grade that is still outstanding after the tenth day of instruction in the next academic-year semester following receipt of the XN grade will be converted into the parenthetical grade. The parenthetical grade will be dropped from the transcript.

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 on 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 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 eleven 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 "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.

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 "D+" 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 D+ 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 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 at announced times during this period. 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.

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 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 chairperson and the chairperson 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
- Freshmen 2nd semester 7 to 21: 1.70
- Sophomores 22 to 51: 1.80
- Juniors and seniors more than 51: 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 standard listed above, effective at the end of any semester or the second summer session.

Dropped for poor scholarship. 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 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 ninety 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 ninety 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 ninety 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, and those courses taken in faculty approved (for credit and grade) study abroad programs through the Lehigh Study Abroad 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 residency 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 Science 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 eighteen honor and course societies. The three best-known are:

- **Phi Beta Kappa.** The desired profile for this Arts and Science honor society consists of:
  - A minimum cumulative GPA of 3.5
  - In addition to a student's major, which might encompass one of the distribution requirements noted below, a student should present a minimum of—
  - Two natural science courses, with at least one lab as part of that instruction
  - Two social science courses
  - Two humanities courses, especially reading/critique of literature beyond basic freshman English. Inclusion of the study of calculus, or advanced mathematics Study of foreign language roughly equivalent to 2nd-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.

- **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.

- **Tau 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

W. Beall Fowler, *interim dean*; James B. Hobbs, *associate dean*; Gary G. DeLeo, *associate dean*; Howard R. Whitcomb, *associate dean*

The College of Arts and Sciences offers several curricular options:

- A four-year curriculum in arts and science, 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 nd a 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.

Courses

Courses offered by departments in the college range from one to six credit hours. A number of departments are modifying their courses and curricula in ways that will, by Fall 1996, significantly increase the number of four-credit courses and decrease the number of three-credit courses. The new four-credit courses will, in general, involve more out-of-class student activity in a variety of learning modes than the three-credit courses they replace. This mixed-credit system will increase opportunities for students to choose between breadth (five-course semester) and depth (four-course semester) in constructing a normal semester of 15-16 credit hours.

Major Programs in the College

The college offers the following major programs:

**Bachelor of Arts Degree**

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

- **Social Sciences:** American studies; anthropology; cognitive science; economics; government; history; international careers; international relations; journalism and communication; journalism/science writing; psychology; science, technology and society studies; social relations (includes anthropology, social psychology, and sociology); sociology; sociology/social psychology; and urban studies.

- **Mathematics and Natural Science:** biology; chemistry; computer science; environmental science; geology; mathematics; molecular biology; natural science; physics; premedical science; preoptometry science.

**Bachelor of Science Degree**

Behavioral neuroscience; biochemistry; biology; chemistry; computer science; environmental science; geological science; geophysics; 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 some sequence of studies as a major field of concentration. A major consists of at least fifteen 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 selects one of these standard majors, a faculty member from the department or program offering the major becomes a student’s major adviser and assists the student in making out the program of study. The final responsibility for meeting both 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 government 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 fifteen hours shall consist of advanced courses. The program must be approved by the major advisers and the dean of the college.

**Multiple majors.** Some students choose to fulfill the requirements of more than one major sequence. A student initiates this by having separate major programs made out by different major advisers.

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.

Students who wish to pursue a second degree in another college or both a B.A. and B.S. degree within the college must have a minimum of thirty additional credit hours beyond the first degree credit-hour requirements in order to qualify for the second degree. Both sets of major and distribution requirements must be met.

**Junior-Year Writing Certification**

The faculty of the College of Arts and Science is committed to the concept that writing is a valuable tool for learning and views the ability to write well as a valuable 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 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 or aerospace studies courses, and a maximum of eight credit hours of Music courses numbered 21-79 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 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.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. A&amp;S 1, Choices and Decisions</td>
<td>1</td>
</tr>
<tr>
<td>(to be completed by the end of the first year)</td>
<td></td>
</tr>
<tr>
<td>B. College Seminar</td>
<td>3</td>
</tr>
<tr>
<td>(taken during the first year)</td>
<td></td>
</tr>
<tr>
<td>C. English Composition</td>
<td>6</td>
</tr>
<tr>
<td>(taken during the first year)</td>
<td></td>
</tr>
</tbody>
</table>

It is recommended that the remaining distribution requirements be completed by the end of the sophomore year. Courses taken within the major department to satisfy a major may satisfy distribution requirements in only one area.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>D. Mathematical Sciences</td>
<td>3</td>
</tr>
<tr>
<td>Chosen from mathematics or logical theory</td>
<td></td>
</tr>
</tbody>
</table>
A minor consists of at least fifteen 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 major adviser 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. Following are established interdisciplinary minors in the College of Arts & Sciences.

**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 is particularly relevant to students interested in law, organizational communication, philosophy, government, marketing, or teaching.

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 minor is administered through the Communication Studies Program in cooperation with the Department of Journalism and Communication. An interdisciplinary committee of faculty members with both teaching and research interests in this area oversees the program. 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 200-level or above. 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 3-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 hours)**
- Comm 130 Public Speaking (3) **and either**
- Comm 143 Persuasion and Influence (3) **or**
- SSP 135 Human Communication

**Elective courses (10-11 credits)** chosen from at least two of these groups. One course must be at the 200-level or above:

**Group I—Public Communication**
- Comm 60 Fundamentals of Speech Communication (3)
- Comm 331 Business and Professional Speaking (3)
- Govt 329 Propaganda and American Politics
- Jour 127 Public Relations Principles (3)
- Jour 229 Public Relations Case Studies (3)
- Jour 246 (IR 246) International Communication (3)
- Jour 306 Applied Public Relations (3)
- Mgt 307 Business Communication Skills
- Mkt 313 Marketing Communications
- Mkt 316 Advertising

**Group II—Communication in Writing**
- Engl 171 Practical Writing (3)
- Engl 355 The Essay (3)
- Jour 123 Basic Science and Technical Writing (3)
- Jour 128 Writing for Public Relations (3)
- Jour 240 Writing for Broadcasting (3)

**Group III—Interpersonal, Group and Organizational Communication**
- Comm 143 Persuasion and Influence
- Mgt 270 Organization Theory and Behavior (3)
- Mgt 321 Organizational Behavior Workshop (3)
- Phil 113 Logic (3)
- Psyc 121 Self and Others (3)
- SSP 125 Small Groups (3)
- SSP 135 Human Communication (3)
- SSP 312 Communication in Groups (3)
- SR 118 Close Personal Relationships (3)

**Group IV—Visual Communication**
- Art 43 Introduction to Graphic Communication (3)
- Art 143 Graphic Communication II (3)
- Art 231 Advanced Graphics (3)
- Jour 141 Photojournalism (3) (Summer Semester only)

**Other Options**
- Comm 325 Special Topics in Communication (3)
- Internships (Consent of department required)
- Jour 361 Internship
- Art 375 Internship

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**Education Minor**

The education minor helps undergraduates explore a career option 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 phenomenon 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. 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, 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) (must be taken concurrently with Educ 314)
- Educ 314 Intern Seminar (2) (must be taken concurrently with Educ 312)
- 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)
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 discourse associated with current environmental issues; others focus on the longer-term adaptations of social systems to changing environmental situations. Only a couple of the courses in the minor have specific pre-requisites; hence, students can easily select a minor program to suit their personal tastes and interests, especially if the minor is declared by the end of the sophomore year.

Each student’s minor program consists of five courses chosen in consultation with the program director from among the courses listed below. The only stipulation is that at least three of the five must be “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, John B. Gatewood, Department of Sociology and Anthropology, Price Hall, Room 10C.

Core Courses (minimum of three)
- Anth/Cls 121 Environment and Culture
- Anth 305 Anthropology of Fishing
- CE 172 Fundamentals of Environmental Pollution
- Eco 311 Environmental Economics
- Eco 314 Energy Economics
- Govt 111 The Politics of the Environment
- Hist 315 American Environmental History
- Jour 125 Environment, the Public, and the Mass Media
- Jour 323 Scientific and Environmental Controversies

Related Course
- Anth 12 Human Evolution and Prehistory
- Anth/Cls 345 Evolution of the State
- Govt 115 Technology as Politics
- Govt 177 Urban Politics
- Jour/STS 124 Politics of Science
- Jour 313 Special Topics in Science Writing
- SSP 165 Contemporary Social Problems

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 fifteen 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)
- Psyc 107 Child Development (3)
- Psyc 108 Adolescent Development (3)
- 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)
- Govt 306 Public Policy Process (3)
- Phil 116 Medical Ethics (3)
- Psyc 77 Drugs and Behavior (3)
- Psyc 107 Child Development (3)
- Psyc 108 Adolescent Development (3)
- Psyc/SSP 109 Adulthood and Aging (3)
- 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)

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 exhibits. Study abroad, particularly in Israel, is encouraged as a means to augment and broaden one's 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, at the Hebrew University summer program, the Hebrew University summer study program in Jerusalem, the kibbutz-study program of the Hebrew University, or the Tel Migne-Ekron archaeological excavation. 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. Silberman, Maginnes Hall.

A minimum of fifteen credit hours is to be selected from the following courses. (A maximum of six 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.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>Hebr 1</td>
<td>Elementary Modern Hebrew I (3)</td>
</tr>
<tr>
<td>Hebr 2</td>
<td>Elementary Modern Hebrew II (3)</td>
</tr>
<tr>
<td>Hebr 11</td>
<td>Intermediate Modern Hebrew I (3)</td>
</tr>
<tr>
<td>Hebr 12</td>
<td>Intermediate Modern Hebrew II (3)</td>
</tr>
<tr>
<td>IR 81</td>
<td>Middle East in World Affairs to 1945 (3)</td>
</tr>
<tr>
<td>IR 82</td>
<td>Middle East in World Affairs Since 1945 (3)</td>
</tr>
<tr>
<td>Phil/Rel 129</td>
<td>Jewish Philosophy (3)</td>
</tr>
<tr>
<td>Phil 133</td>
<td>Medieval Philosophy (3)</td>
</tr>
<tr>
<td>Rel 73</td>
<td>The Jewish Tradition (4)</td>
</tr>
<tr>
<td>Rel 111</td>
<td>Jewish Scriptures/Old Testament (4)</td>
</tr>
<tr>
<td>Rel 112</td>
<td>Varieties of Judaism in the Greco-Roman World (4)</td>
</tr>
<tr>
<td>Rel 121</td>
<td>Sources for the Life of Jesus: Jewish and Christian Context (4)</td>
</tr>
<tr>
<td>Rel 130</td>
<td>The Mystical Tradition: Judaism (4)</td>
</tr>
<tr>
<td>Rel 132</td>
<td>Hasidic Tales (4)</td>
</tr>
<tr>
<td>Rel/WS 13</td>
<td>Women in Jewish History (4)</td>
</tr>
<tr>
<td>Rel 139</td>
<td>Jewish Folklore (4)</td>
</tr>
<tr>
<td>Rel 150</td>
<td>Judaism in the Modern World (4)</td>
</tr>
<tr>
<td>Rel 152</td>
<td>American Judaism (4)</td>
</tr>
<tr>
<td>Rel/Hist 154</td>
<td>The Holocaust: History and Meaning (4)</td>
</tr>
<tr>
<td>Rel 155</td>
<td>Jewish Thought since the Holocaust (4)</td>
</tr>
<tr>
<td>Rel 156</td>
<td>Israel, Zionism, and the Renewal of Judaism (4)</td>
</tr>
<tr>
<td>Rel/WS 158</td>
<td>Sex and Gender in Judaism: The Feminist Critique (4)</td>
</tr>
<tr>
<td>Rel 174</td>
<td>Contemporary Theology (4)</td>
</tr>
<tr>
<td>Rel 196</td>
<td>Judaism in Israel and the United States (4)</td>
</tr>
<tr>
<td>Rel 371</td>
<td>Directed Readings (1-4)</td>
</tr>
<tr>
<td>US 28</td>
<td>The American Jewish Community (3)</td>
</tr>
</tbody>
</table>

**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 15-16 credit hours, chosen from economics, history, government, Spanish, anthropology, and I.R. in discussion with the coordinator, Antonio Prieto, modern foreign languages, Maginnes Hall.

Requirements (6-7 credits)

A. History/Culture (3 credits). Choose one of the following:

- Hist 49 History of Latin America (3)
- Hist 50 History of Latin America (3)
- Span 152 The Cultural Evolution of Latin American (taught in Spanish) (3).

B. Language (3-4 credits). Choose one of the following:

- Span 2 Elementary Spanish II (3)
- Span 12 Intermediate Spanish II (3)

Elective courses (9 credits) chosen from the following courses.

No more than two courses may be taken in any one department:.

- Anth 178 Mesoamerican Archeology (3)
- MFL 51 Contemporary Hispanic-American Literature (3)
- MFL 53 The Hispanic World and Its Culture (3)
- Eco 305 The Economic Development of Latin America (3)
### Russian Studies
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 merely to do focused work on the culture and society of the former USSR.

The minor in Russian Studies requires eighteen to twenty-two credit hours of formal course work, chosen in consultation with the program director, Rajan Menon, department of International Relations.

#### required courses (15-19 hours)
- Two semesters of college-level Russian (at least three credit hours each), based on the student's level of competence, or two semesters of Russian literature in translation (6-10)
- Govt 361 Soviet and Post-Soviet Politics
- Hist 261 Russia to 1855
- Hist 262 Russia since 1855
- IR 167 Diplomacy of Russia to 1945, or
- IR 168 Diplomacy of Russia since 1945

#### elective course (3 credit hours); one course from the following:
- Any other Russian-language course
- Eco 309 Comparative Economic Systems
- Govt 318 Communist Political Systems
- Hist 261 or 262 (whichever is not taken in the above section)
- IR 167 or 168 (whichever is not taken in the above section)
- IR 367 Seminar in the International Relations of Russia and Eastern Europe
- Special Topics courses in other areas such as psychology or social relations, with permission
- Field Study in the former Soviet Union for academic credit under Special Topics
- Other courses approved by the director of Russian Studies.

### Science, Technology and Society Program
The Science, Technology and Society (STS) Program is a broad-based effort on the part of faculty members from all colleges to foster undergraduate courses concerned with the interrelationships between scientific and technological advancement and the quality of human life.

The STS Program offers a minor in Science, Technology, and Society Studies, consisting of fifteen credit hours drawn from a variety of departments. For a full description of the program and courses offered, see Section V.

### Urban Studies
The minor program in Urban Studies is a means of gaining broad insight into the nature and potentialities of the social sciences, besides being an appropriate vocational choice for students in fields such as civil engineering, management, architecture, and social work.

Urban Studies is designed to promote basic understanding of social processes, so that students will learn to perceive in their communities opportunities for productive enterprises of their own. For some this will mean careers in public service, but others may contribute much to the betterment of society by successful work in the private sector. The minor in Urban Studies should be of particular interest to students in the College of Engineering and Applied Sciences as well as the College of Business and Economics who wish to maximize the educational value of their elective courses.

The minor consists of eighteen credit hours of course work selected in consultation with the program director, based on the needs and interests of the student with due concern for the overall intellectual coherence of the program.

Certain other courses in relevant disciplines may be included by permission of the director of urban studies, David Curtis Amidon, Jr., minor adviser, 232 Chandler-Ullmann.

#### required course (3 credit hours)
- US 61 The Study of Urbanization

#### elective courses (15 credit hours); from the following:
- Arch 107 History of American Architecture
- Arch 210 20th-Century Architecture
- Arch 213 The City
- Eco 312 Urban Economics
- Eco 337 Transportation and Spatial Economics
The minor in Women's Studies engages students in the study of social order and their world. Students are encouraged to reevaluate traditional assumptions about human experience. Students in Women's Studies courses are acknowledged 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 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.

The minor in Women's Studies consists of a minimum of 18 credit hours (6 courses). 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 4 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)
WS 101 Introduction to Women's Studies (3)
and one of the following:
WS 271 Independent Reading and Research (1-3)
WS 330 Internship in Women's Studies (3)
WS 350 Senior Seminar (3)

elective courses (12 credit hours)
WS41/SR41 Human Sexuality (3)
WS 121/Art 121 Women and Art (3)
WS 123/Anth 123 Cultural Construction of Gender (3)
WS 124/Hist 124 Women in America (3)
WS 126/Phil 126 Feminism and Philosophy (3)
WS 138/Rel 138 Women in Jewish History (3)
WS 152/Clss 152 Women in Antiquity (3)
WS 158/Rel 158 Sex and Gender in Judaism: The Feminist Critique (4)
WS 179/Govt 179 Politics of Women (3)
WS 184/Rel 184 Religion, Gender and Power (4)
WS 253/Hist 253 Women in European History, 1500-Present (3)
WS 311/Engl 311 Literature of Women (3)
WS 318/Psych 318 Seminar in Gender Psychology (3)
WS 325/Hist 325 History of Sexuality and the Family in the U.S. (3)
WS 326/Hist 326 Social Class in American History (3)
WS 341/Soc 341 Women and Health (3)
WS 351/Soc 351 Gender and Social Change (3)
WS 364/Soc 364 Sociology of the Family (3)
WS 91, 191, 272, 291, 371, 381, 382, 391, 392 Special Topics (1-3)

In addition, new courses may be offered annually. Students should check with the Director for an updated list.

College Scholar Program
The Roy Eckardt College Scholar Program is intended to cater to students who show outstanding academic promise or unusual creativity, those whose interests are not satisfied by traditional programs, and those who are deeply committed to a particular subject. 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 and the rest in the following two years. Applications from entering freshmen are evaluated by the Admissions Office and the College Scholar Advisory Committee on the basis of 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 Committee on the basis of their academic records and written statements of educational goals and recommendations from 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 obligated to obtain 121 credits, including A&S I and the junior writing requirement,
take at least one college scholar seminar, and pursue departmental or interdisciplinary majors. With the approval of the program director, they design their own academic plans. They are released from distribution requirements and, if necessary, modifications may be made in major requirements. Responsibility for the student's overall program lies with the director who cooperates closely with the major adviser. In each of the final two semesters, the student receives up to six credits for work with a faculty member, leading to a senior project of substantial dimensions. This can take whatever form is appropriate to the nature of the subject. 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 P. H. Duffy, 340 Maginnes Hall) and the chairperson 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 throughout the year, lectures, plays, musical events, and other cultural activities in the Lehigh Valley and nearby cities.

**College Seminar 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 college seminar taught by a member of the faculty. With ten to twenty students per class, these seminars 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.

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. Recent offerings have included: "The Jazz Age," "The Death of Western Civilization," "Cosmic Physics," "The Soviet Collapse and Russia's Future," "Fate and Character," "AIDS and Society," "Acting," "In Search of Big Foot."

Whatever the topic, seminars 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 3-credit seminar fulfills the College Seminar requirement but does not fulfill any distributional requirements.

**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, psychology, chemistry, engineering, 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 obtain information from the health professions advisory committee in planning their courses with their academic advisers.
Combined-Degree Program in Medicine  
(Hahemmann University School of Medicine)  
In cooperation with the Medical College of Pennsylvania, the university offers an accelerated six-year 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 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 academic years and two summers at Lehigh, during which time ninety-one credit hours are earned toward the 121 credits required for the baccalaureate degree. Students entering Lehigh with sufficient advanced placement credit may reduce or entirely eliminate the second summer session. The program also offers the flexibility of a third year at Lehigh to pursue additional coursework or extracurricular activities. 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 college, students will have acquired the necessary additional credit hours for the baccalaureate degree.

During the first two 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/HUSM receives student grades and monitors student progress through feedback from Lehigh staff. Students are expected to maintain an overall grade point average 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 acceptance. This program also requires that students take the Medical College Admissions Test. The results will be evaluated by the Committee prior to final acceptance. It is expected that the three numberered scores be "99" 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. In addition, the student may elect to take additional time at Lehigh if he or she feels that this would be beneficial. Should this occur, the student would be eligible to defer matriculation at the medical school for a period of time agreed to by the student and the medical college.

Application for admission to the program is made through the Lehigh office of Admission. Criteria for admission include SAT scores (minimum combined score of 1300 original scale/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 Medical College.

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.

<table>
<thead>
<tr>
<th>Year 1: fall</th>
<th>spring</th>
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<tbody>
<tr>
<td>Arts 1 (1)</td>
<td>Engl 2 (3)</td>
</tr>
<tr>
<td>Engl 1 (3)</td>
<td>EES 31, 32 (4)</td>
</tr>
<tr>
<td>Chm 21, 22 (5)</td>
<td>Math 22 or 44 (3-4)</td>
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<tr>
<td>Math 21 or 41 (3-4)</td>
<td>Social Science (3)</td>
</tr>
<tr>
<td>Humanities (3)</td>
<td>Freshman Seminar (3)</td>
</tr>
</tbody>
</table>

**Summer 1:**

| Chm 51, 53 (4) |
| Chm 52, 58 (4) |
| Elective (free) (3) |
| Elective (free) (3) |

<table>
<thead>
<tr>
<th>Year 2: fall</th>
<th>spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phy 11, 12 (5)</td>
<td>Phy 13, 14 (4)</td>
</tr>
<tr>
<td>Bios 31, 32 (4)</td>
<td>Chm 31 (3)</td>
</tr>
<tr>
<td>Math 23 or Math elective (3-4)</td>
<td>Bios 101, 102 (4)</td>
</tr>
<tr>
<td>Humanities (3)</td>
<td>Social Science (3)</td>
</tr>
<tr>
<td>Elective (free) (3)</td>
<td>Writing Intensive (3)</td>
</tr>
</tbody>
</table>

**Summer 2:**

| Humanities (3) |
| Social Science (3) |
| Elective (free) (3) |

Combined-Degree Program in Dentistry

The university, in cooperation with the School of Dental Medicine at the University of Pennsylvania, offers an accelerated program that enables selected students to earn a combined baccalaureate and doctor of dental medicine degree after a minimum of seven years of study at the two institutions.

The program includes three academic years during which time ninety-two credit hours are earned toward the baccalaureate degree. The next four years are spent in the regular program of dental education in Philadelphia.

During the first three years at Lehigh, students are expected to make satisfactory progress in the academic areas as well as in the areas of personal growth, developing those attributes ultimately needed to become a dentist. Students must maintain a minimum 3.0 grade-point average throughout their three years at Lehigh and are required to take the Dental Admissions Test.

The dental school reserves the right to withdraw an offer of acceptance if academic or personal concerns cause the college to question a student's ability to function as a dentist. The dental school also reserves the right to require that students spend additional time at Lehigh if the school feels that this is necessary to insure the student's academic or personal maturation.

Application to the program occurs when a student applies to Lehigh University. The dental school takes action on the applicant in the spring of an academic year. Final decisions are forwarded to Lehigh University about March 20. The
applicant is notified of joint acceptance by Lehigh University. Admission is based on SAT scores (a minimum combined score of 1200 original scale/1270 recentered scale), scholastic achievement, maturity, and motivation for dental school. Application deadline is January 1.

Year 1, fall
Arts 1 (1)
Engl 1 (3)
Math 41 (3)
Chm 21, 22 (5)
Humanities (3)

Year 1, spring
Engl 2 (3)
Math 44 (3)
EES 31, 32 (4)
Freshman Seminar (3)
Social Science (3)

Year 2, fall
Chm 51, 53 (4)
Bios 31, 32 (4)
Humanities (3)
Elective (free) (3)

Year 2, spring
Chm 52, 58 (4)
Bios 101, 102, 104
Social Science (3)
Elective (free) (3)

Year 3, fall
Phy 11, 12 (5)
Life Science elective (3)
Humans (3)
Writing Intensive (3)
Elective (free) (3)

Year 3, spring
Phy 13, 14 (4)
Life Science elective (3)
Humans (3)
Social Science (3)
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 to 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 1100 SAT original score/1180 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 Lehigh student, a minimum overall 3.2 grade point average 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 ninety eight credit hours are earned toward the baccalaureate degree. Upon maintaining a minimum 3.2 grade point average in the required 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 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.
College of Business and Economics

James W. Schmotter, dean; Therese A. Maskulka, associate dean, director of undergraduate programs; Kathleen A. Trelcer, assistant dean, director MBA program; Stephen G. Buell, chairperson, department of business; Vincent G. Munley, chairperson, department of economics; Michael G. Kolchin, director of graduate and professional education, Larry W. Taylor, director of the 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 a program of undergraduate study designed to provide an understanding of the complexities of managerial processes in society, both within and outside the business firm.

The College of Business and Economics consists of two departments: the Department of Business and the Department of Economics. The Department of Business offers undergraduate majors in accounting, finance, management and marketing, and courses in law. 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 Science.

Many of the most difficult societal problems today involve decision-making, conflict resolution, and the efficient and effective management of human 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 program stresses analytical and communication skills, and problem-solving techniques. Educational breadth equivalent to many liberal arts programs is accomplished 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 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.

Undergraduate objectives may be summarized as follows:

- To increase written and oral communication skills.
- Through a common body of knowledge, to stimulate interest in and acquaint a student with basic business and economic systems of resource allocation, financial management, management of human and physical resources, information systems, financial and managerial accounting, pricing and distribution;
- To provide breadth of appreciation of the scientific, technological, social, and human features of the world in which business is carried on;
- To provide tools which permit rigorous analysis of business problems and to foster a capacity for continuing professional development;
- To undertake advanced courses with upperclass students as a prelude to a professional career or to graduate study;
- Through a major, to provide each student with an in-depth learning experience in at least one area of business or the economy in which business operates, such as accounting, economics, finance, management, or marketing;
- To increase written and oral communication 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, management, and marketing.

This education in fundamental principles, and problem-solving techniques provides graduates with various options. Some of the 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. Others teach economics or administrative science.

Business today cannot be approached with narrow or superficial vocational training. Its problems are strongly conditioned by the state of the economy, a complex array of international aspects, and other major social and ethical issues. Thus a strong basis in the social sciences is essential to understanding the nature of business organizations. The
student also must be familiar with physical sciences and technology. Finally, mathematics and computer systems are essential elements of modern decision-making processes. An introduction to all of these is provided in the undergraduate program in business and economics.

**Variety of Options**
The student of today must be provided with options. Initiative and motivation would be discouraged in a rigid curriculum. To avoid such rigidity, the necessary exposures to science, language, and other arts are 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 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, Center for Innovation Management Studies, Center for Social Entrepreneurship, 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.

The college is also associated with the Center for International Studies, and the Iacocca Institute.

**Bachelor of Science in Business and Economics**
To obtain the bachelor of science degree in business and economics, 120 credit hours are required. A writing requirement, which is included within the required 120 credit hours, is also a part of the college curriculum.

**College Core Requirements (57 credits)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course 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</td>
<td>Composition and Literature: Fiction, Drama, Poetry (3)</td>
</tr>
<tr>
<td>Math 41</td>
<td>BMSS Calculus I (3)</td>
</tr>
<tr>
<td>Math 44</td>
<td>BMSS Calculus II (3)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>Eco 11</td>
<td>Principles of Microeconomics (3)</td>
</tr>
<tr>
<td>Mgt 1</td>
<td>Introduction to Business Computing (3)</td>
</tr>
<tr>
<td>Eco 115</td>
<td>Applied Microeconomics (3)</td>
</tr>
<tr>
<td>Eco 145</td>
<td>Statistical Methods (3)</td>
</tr>
<tr>
<td>Eco 229</td>
<td>Money and Banking (3)</td>
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<tr>
<td>Acct 151</td>
<td>Introduction to Financial Accounting (3)</td>
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<tr>
<td>Acct 152</td>
<td>Introduction to Managerial Accounting (3)</td>
</tr>
<tr>
<td>Acct 211</td>
<td>Management Information Systems in Business (3)</td>
</tr>
<tr>
<td>Law 201</td>
<td>Legal Environment of Business (3)</td>
</tr>
<tr>
<td>Mkt 211</td>
<td>Contemporary Marketing (3)</td>
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<tr>
<td>Fin 225</td>
<td>Business Finance (3)</td>
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<tr>
<td>Mgt 269</td>
<td>Management of Operations in Organizations (3)</td>
</tr>
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<td>Mgt 270</td>
<td>Organization Theory and Behavior (3)</td>
</tr>
<tr>
<td>Mgt 301</td>
<td>Business Management Policies (3)</td>
</tr>
<tr>
<td>Mgt 306</td>
<td>Entrepreneurship and Business Policy (3)</td>
</tr>
</tbody>
</table>

**Major Program (15 credits)**
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 five major programs: accounting, economics, finance, management, and marketing.

A grade point average 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 coursework 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 approved 300-level economics courses.

**Planning Courses of Study**
In addition to freshman English and mathematics requirements, each freshman enrolled in the College of Business and Economics registers for Eco 11 and Eco 12. The College of Business and Economics assigns students to take Mgt 1 in either the fall or spring semester of their freshman year. Students are encouraged to consider substituting Math 21 and 22 for the Math 41 and 44 requirement because Math 21 and 22 are prerequisites for many courses in engineering and science. Acct 151 is taken in the first semester of the sophomore year.
Freshman Year

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td><strong>first semester</strong></td>
<td></td>
</tr>
<tr>
<td>Engl 1</td>
<td>3</td>
</tr>
<tr>
<td>Math 41</td>
<td>3</td>
</tr>
<tr>
<td>Eco 11</td>
<td>3</td>
</tr>
<tr>
<td>Mgt 1 or elective</td>
<td>3</td>
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<tr>
<td><strong>second semester</strong></td>
<td></td>
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<tr>
<td>Engl 2</td>
<td>3</td>
</tr>
<tr>
<td>Math 44</td>
<td>3</td>
</tr>
<tr>
<td>Mgt 1 or elective</td>
<td>3</td>
</tr>
<tr>
<td>Eco 12</td>
<td>3</td>
</tr>
</tbody>
</table>

15 credit hours

The pass-fail option is available for students in the college for elective courses only. Students desiring to obtain Lehigh credit for courses taken at other institutions must obtain a petition form from the registrar's office and obtain the 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.

**College of Engineering and Applied Science**

Harvey G. Stenger, dean
Richard N. Weisman, associate dean

The College of Engineering and Applied Science offers the bachelor of science degree in thirteen 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 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 or curricula 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 Accreditation Board for Engineering and Technology. Programs in chemistry and physics have been approved by the program review committee in these disciplines.

**Accredited by the Computing Science Accreditation Board, Inc.

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 sciences, 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 means of a petition following consultation with curriculum advisors. 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 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.

Students who do a co-op assignment or have significant
involvement in noncredit major extracurricular activities may have up to six credit hours of free electives waived upon petition to the department chairperson. These petitions must be completed and approved prior to the final semester before graduation.

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 and with the approval of the dean of the Graduate School, 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 program contains at least fifteen 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.

Technical and scientific minors are available in chemical processing (not open to chemical engineers), molecular biophysics (not open to engineering physicists or fundamental sciences majors concentrating in this area), production management (not open to industrial engineers), fluid mechanics, solid mechanics, manufacturing systems engineering (for materials majors only), and materials science (for industrial engineering majors only). A student in the college who is able to incorporate electives within the curriculum that satisfy the requirements of a minor offered in the College of Arts and Science may, with the permission of the adviser in that college, earn the minor.

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

Freshman year, first semester (15-16 credits)
- Engl 1: 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: Analytic Geometry and Calculus I (4)
- Engr 1: Engineering Computations (3) or Humanities, or Social Science elective (3-4) and Introduction to Engineering (1)

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

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

Basic Requirement: English and Economics (3 courses totaling a minimum of 9 credit hours):
- Students must complete English 1 or 3, English 2, 4, 5, 6, 8 or 10, and one introductory course in Economics.

Advanced Requirement: Breadth and Depth (A minimum of 5 courses whose total credit hours plus the total credit hours in the basic requirement equals a minimum of 24 credit hours. These courses must be selected from the departments/programs listed in Table 2, excluding those courses in Table 1.)

Depth: A minimum of 3 courses totaling at least 9 credit hours must be in one program/department, of which at least one course must be at the 100 level or above. This course sequence establishes HSS depth.

Breadth: A minimum of 2 courses totaling at least 6 credit hours. These courses must be taken in department/programs different from the courses which establish depth. These courses must not be cross listed with the department/program chosen for depth. These courses, plus the courses which established depth and the courses in the basic requirement, establish HSS breadth.
TABLE 1
Courses which cannot be used to satisfy the HSS requirement.

<table>
<thead>
<tr>
<th>Architecture</th>
<th>147, 351, 352</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications</td>
<td>60, 130, 144, 331</td>
</tr>
<tr>
<td>Economics</td>
<td>101, 145, 351, 352, 357</td>
</tr>
<tr>
<td>English</td>
<td>all freshman composition courses, 171, 173</td>
</tr>
<tr>
<td>Government</td>
<td>313, 314</td>
</tr>
<tr>
<td>Music</td>
<td>11 through 79</td>
</tr>
<tr>
<td>Philosophy</td>
<td>113, 114, 214</td>
</tr>
<tr>
<td>Psychology</td>
<td>110, 121, 160-162, 176, 210, 277, 35, 337, 352, 373, 375, 377, 382</td>
</tr>
<tr>
<td>Social Relations</td>
<td>41, 111, 112</td>
</tr>
<tr>
<td>Theater</td>
<td>15, 61, 111, 113, 116, 161, 181, 214, 216</td>
</tr>
</tbody>
</table>

TABLE 2
Programs/Departments in HSS

<table>
<thead>
<tr>
<th>Arts (ARTH)</th>
<th>African American Studies (AAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture (ARCH)</td>
<td>Economics (ECO)</td>
</tr>
<tr>
<td>Arts and Science (AS)</td>
<td>Education (EDUC)</td>
</tr>
<tr>
<td>Classical Civilization (CLSS)</td>
<td>Government (GOVT)</td>
</tr>
<tr>
<td>Special Education (SPED)</td>
<td>History (HIST)</td>
</tr>
<tr>
<td>Ancient Greek (GRK)</td>
<td>English (ENG)</td>
</tr>
<tr>
<td>Latin (LAT)</td>
<td>Relations (IR)</td>
</tr>
<tr>
<td>Modern Foreign Language (MFL)</td>
<td>International (INT)</td>
</tr>
<tr>
<td>Chinese (CHIN)</td>
<td>Journalism (JOUR)</td>
</tr>
<tr>
<td>Communications (COMM)</td>
<td>French (FREN)</td>
</tr>
<tr>
<td>German (GERM)</td>
<td>Psychology (PSYC)</td>
</tr>
<tr>
<td>Science Technology and Science (STS)</td>
<td>Special Education (SPED)</td>
</tr>
<tr>
<td>Hebrew (HEBR)</td>
<td>Special Education (SPED)</td>
</tr>
<tr>
<td>Social Relations (SR)</td>
<td>Psychology (PSYC)</td>
</tr>
<tr>
<td>Japanese (JPNS)</td>
<td>Anthropology (ANTH)</td>
</tr>
<tr>
<td>Russian (RUSS)</td>
<td>Sociology/Social Psychology (SSP)</td>
</tr>
<tr>
<td>Spanish (SPAN)</td>
<td>Urban Studies (US)</td>
</tr>
<tr>
<td>Music (MUS)</td>
<td>Women's Studies (WS)</td>
</tr>
<tr>
<td>Women's Studies (WS)</td>
<td>Philosophy (PHIL)</td>
</tr>
</tbody>
</table>
| Asian Studies (ASIA) | 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 on page 32 of the catalog under the heading Minor Programs in the College. Excluded are minors in Education and Communications, and included is a minor in Economics. (See page 30.) Because students must fulfill the above 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 six such unrestricted electives. Written permission to pursue a minor in HSS must be obtained from the sponsoring department, approved by the student's engineering faculty advisor and the Director of HSS, and filed with the Registrar. A student successfully completing a HSS minor will receive a certificate in recognition of this accomplishment. Other issues and constraints:
1. None of the courses taken to satisfy the HSS requirement can be taken pass/fail.
2. The introductory level course in any language can only be used to meet the HSS requirement if a second course in the same language is successfully completed. 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, Bioprocessing Institute, Center for Innovation Management Studies, Center for Molecular Bioscience and Biotechnology, Chemical Process Modeling and Control Center, Emulsion Polymers Institute, Energy Research Center, Fritz Laboratory, Iacocca Institute, Institute of Fracture and Solid Mechanics, Institute of Metal Forming, Institute of Thermodynamic Engineering and Science, Materials Research Center, Sherman Fairchild Center for Solid-State Studies, Zettlemoyer Center for Surface Studies. 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 Science 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 colleges. 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 materials degree, among others. The fifth-year program in the School of Education enables those receiving a B.A. 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 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.

Arts/M.B.A. Program
Students in the College of Arts and Science may enroll in a special arts/master of business administration program by completing the 43 credit hours of courses listed below in the suggested sequence, while completing their major in one of the B.A. programs in the college during their first four years. At the end of this period, if they are admitted to the Graduate School, they may be granted their M.B.A. degree upon completion of an additional 36 hours of course work. This can usually be accomplished in two regular semesters and two summer sessions.

All courses listed below under "other required courses" must have a grade of B minus or better in order to be credited toward the M.B.A. program.

The following comprise the required courses during the four years in the college:

required background courses
* Eco 11 Principles of Microeconomics (3) or
  * Eco 12 Principles of Macroeconomics (3)
* Math 41 BMSS Calculus (3) and* Math 44 BMSS Calculus II (3)

or
* Math 21 Analytical Geometry & Calculus (4)
  and

* Math 22 Analytical Geometry and Calculus II (4)
  * Mgt 1 Intro to Business Computing (3)

courses to be used as waivers for M.B.A. courses

** Eco 145 Statistical Methods (3)

or

IE 121 Applied Engineering Statistics (3)

** IE 222 Operations Research-Deterministic

** IE 222 Operations Research-Deterministic

** Law 201 Legal Environment of Business (3)

** Eco 229 Money and Banking (3)

* recommended in the freshman year
** recommended in the sophomore year
*** junior standing required for this course

Note: Students must take both Acct 152 and Acct 324 to waive Acct 413; and students must take both Eco 119 and Eco 229 to waive Eco 409.

Engineering-M.B.A. Program
The bachelor in engineering-master of business administration two-degree program is designed to meet the needs of especially competent students in any engineering curriculum who want to add to their engineering studies training in business management at an advanced level.

The time involved will vary depending on the student's background. One or more summer sessions in addition to two or more regular semesters of study may be necessary after completion of the bachelor's degree in engineering to attain the M.B.A. or M.S. in management science. All candidates must take the Graduate Management Admission Test and must meet the standards for admission into The Graduate Department of Business at Lehigh University.
School.

For background courses required for the master of business administration program, engineering students should read Section IV, Graduate Study in Business and Economics, and consult with Kathleen Trexler, Assistant Dean and MBA Director, College of Business and Economics as early as possible.

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:

AfroAmerican 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.

International Programs at Lehigh

"The University emphasizes the development of future leaders in our global society as first among Lehigh's purposes..." The International Mission Statement, Lehigh University

Office of International Education

Anne H. Thomas, Director, 343 Whitaker, 5 E. Packer Ave., Bethlehem, PA, 18015; (610) 758-4859. Fax. (610) 974-6454. E-mail: AHT0@lehigh.edu.

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 is a university-wide resource for students and scholars from abroad, for U.S. students studying abroad, and for U.S. students and faculty who are interested in the global focus. Its mission is to advance, promote, and serve the Lehigh community through the internationalization 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; and integrating international students and scholars and Lehigh Abroad returnees into the international dimension of the University.

International Students and Scholars

Gisela M. Nansteel, Immigration Coordinator, 343 Whitaker, 5 E. Packer Ave., Bethlehem, PA, 18015; (610) 758-4859. Fax. (610) 974-6454. E-mail: GMN0@lehigh.edu. WWW: http://www.lehigh.edu/intnl/intnl.html

The Office of International Education (OIE) serves the unique needs of foreign nationals who come to Lehigh as students, scholars, faculty and staff members, and their families. More than 900 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.

Services

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

A variety of cross-cultural programs are initiated by the OIE, including undergraduate and graduate orientations, an International Advisory Committee, a Student-Friend program, spouse conversation groups, valley-wide workshops and seminars on immigration matters, international tax advising, trips, and the Annual 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 orientation. International orientation takes place in conjunction with other programs offered by the undergraduate admissions office and/or the graduate school, starting immediately before the university-wide orientation at the beginning of each semester. Issues discussed include filing for a social security number, opening a banking account in the United States, health insurance, and cultural and social customs. International Orientation is a time to become accustomed to life in America, and to meet other foreign students. Orientation closes with a barbecue in honor of the entire international population at Lehigh which is hosted by the University President.

Many people find it helpful to have an American friend to "show them around" for the first few weeks. The Student-Host program is designed to help with the adjustment to life at Lehigh. Students meet their host friend during orientation. Hosts can become lifelong friends, or just a shoulder to lean on until you get to know the University.

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, the bazaar is the international students' opportunity to entertain
the University. Student organizations offer their favorite home country foods, dances, art work and culture in an event which is unrivalled for international flavor.

Lehigh University is committed to providing an international experience which is rivalled by none. To this end, an International Administration Team consisting of administrators across campus 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, and the alumni office. The team works to enhance the Lehigh experience for foreign nationals by providing quality services to students, scholars, alumni, parents and families.

Special Services for International Students

**Career Services:** Advising and workshops for careers for international students.

**CISIH:** Council for International Hospitality and Service, a Lehigh Valley community friend family organization.

**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 with medical personnel to 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 over vacation time periods.

**Immigration/Visa Advising:** Complete service.

**International Club:** An undergraduate campus-wide club for all international students. The club 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:** Provides tutors in writing, math and science.

**Lehigh Global Network:** An alumni outreach program dedicated to establishing alumni organizations worldwide.

**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:** The Beta Pi chapter of this national organization is at Lehigh, see below.

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

"Lehigh University recognizes that in the future, every aspect of life will involve a greater diversity of people and cultures. A learning experience outside the U.S. at a quality institution of higher education is an important component of a Lehigh education..." - Lehigh Abroad Mission Statement

**Lehigh Abroad**

Casimer Sowa, Lehigh Abroad Program Officer, 344 Whitaker, 5 E. Packer Ave., Bethlehem, PA 18015; (610) 758-3351; Fax (610) 974-6454; E-mail CMS2@lehigh.edu, WWW: http://www.lehigh.edu/~intl/intl.html

The Lehigh Abroad office maintains a list of approved semester and year programs 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 main university contact for students interested in study abroad is the Lehigh Abroad Program Officer. The Program Officer advises students and refers them to the appropriate faculty or staff member. Students can take advantage of a resource room and an electronic bulletin board (ABROAD) for the Lehigh community interested in going abroad. Group and individual advising sessions take place every week. Lehigh Abroad also provides a series of required pre-departure orientation meeting for all students going abroad, continuous registration at Lehigh, and the International.

Additionally, Lehigh University maintains formal agreements with universities in the United Kingdom and with two institutions in France. Students selected through faculty interviews for these programs can study for a year at the University of Edinburgh, the University of Kent, London School of Economics and Political Science, the University of Nottingham, or the Universite Paul Valery in Montpellier, France. Students can study for a semester at the University of Buckingham or either a semester or year at the University College London, the University of York, or the Ecole Superieure de Commerce et d'Administration des Enterprises de Poitiers - a business school in France.

Students may also go on exchange to Russia and other republics of the former Soviet Union through Lehigh's membership in the American Collegiate Consortium for East-West Cultural and Academic Exchange.

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 Maginnis, 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 post graduate study/research abroad for students with a bachelor
50 Undergraduate Studies III

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 Foreign Languages and Literature offers limited merit scholarships. Contact MFL, 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 with grades is given for approved inter-institutional agreement programs endorsed by Lehigh faculty. On other programs, credit is given for a grade of C or higher, but no grades are recorded.

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:
C Fall or Year programs: February 1
C 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 Abroad maintains a list of approved summer study abroad programs. The Program Officer 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:
C Introductory session and preliminary application: March 1
C Completion of application process: April 1

Lehigh University also offers faculty-led summer study abroad programs in various parts of the world through the Office of Continuing, Distance and Summer Studies, Johnson Hall, 36 University Drive, Bethlehem, PA, 18015; (610) 758-3935.

Lehigh University sponsors through the Lehigh Valley Association of Independent Colleges (LVAIC), several six-week summer language programs in Europe and Mexico.

Honor Society for International Scholars
Anne H. Thomas, Advisor, 343 Whitaker, 5 E. Packer Ave., Bethlehem, PA, 18015; (610) 758-4859. Fax,(610) 974-6454. E-mail: AHTO@lehigh.edu. WWW: http://www.lehigh.edu/intnl/intnl.html

Lehigh's Beta Pi chapter of Phi Beta Delta, the international honorary 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.
English as a Second Language
Judith Rance-Roney, Director, 33 Coppee Drive, Bethlehem, PA, 18015, (610) 758-6099.
The English as a Second Language Program (ESL) offers academic semester and year courses for enrolled undergraduate and graduate students and their families. In addition, academic support is provided for ESL students through free individual and small group tutoring and conversation groups; through an academic resource center housing books, tapes, and computer programs, and in low-cost language enrichment courses.

Courses. After placement testing, undergraduates accepted by the ESL Program and the English Department may take English 3 and English 5 (ESL) in substitution for English 1 and 2.

Both undergraduate and graduate students may select from a variety of ESL credit courses in conversation, accent reduction, reading, and writing offered throughout the year.

The TLC (The Lehigh Community) Program offers non-credit enrichment ESL courses at a low cost to enrolled students and members of their families and to members of the surrounding community.

Intensive 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 in the near future. STEP/UP is a pre-university program to enhance skills in academic reading and writing, formal academic language, and an orientation to U.S. culture and student survival skills. Students entering STEP/UP should be at a high intermediate or advanced English level.

International Multimedia Resource Center
Neil Toporski, Director, IMRC, 470 Maginnes; (610) 758-6067.
Within the IMRC are a multimedia computer lab dedicated primarily to foreign language multimedia applications and the World View Room providing a regular daily schedule of foreign language news and feature programming received via international satellite TV networks. The multimedia lab features a network of IBM PS/2 Model 80 computers with laser disk players, VCRs, and CD-ROMs designed for use with multimedia software. The World View Room features a comfortable lounge with a large screen rear-projection TV, an assortment of foreign newspapers, journals and magazines; shortwave radio, a variety of visitors—everything to inspire a good international educational and cultural atmosphere.

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 extramural 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 met 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 semester, journalism, public administration, foreign policy semester and justice semester.

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 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
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 policy of the Graduate School provides 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 and;
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
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 MUIHLENBERG 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.

The General College Division
The General College Division supplements the mission of the established undergraduate curricula by providing: an opportunity for persons not planning to qualify for a degree to pursue work, either of a general or specialized nature, which their preparation and interests make desirable; 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 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 an application, at least one month prior to start of the semester in which they hope to enroll, to the undergraduate admissions office. 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 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 in the division are not permitted to take courses using their optional Pass/Fail grading system, or cross register for courses in the L.V.A.I.C.

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 is also 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 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 and Research

The Graduate School

Lehigh began awarding graduate degrees in 1882. The first recipient, T.H. Hardcastle, 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 1895 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.

College of Arts and Science
W. Beall Fowler, interim, dean

Within the College of Arts and Science, professionally oriented students may pursue advanced degrees in chemistry (M.S., Ph.D., D.A.), English (M.A., Ph.D.), geological sciences (M.S., Ph.D.), government (M.A.), history (M.A., Ph.D.), mathematics (M.S., Ph.D.), physics (M.S., Ph.D.), psychology (M.S., Ph.D.), social relations (M.A.), and applied social research (Ph.D.).

Although degree requirements vary from department to department, most departments require a combination of formal coursework and independent research. Students work closely with a faculty adviser both in formulating and carrying out their research programs. Given the nature of the liberal arts, these programs commonly involve faculty and/or coursework from more than one department or a department and research center/institute. Students interested in such an interdisciplinary approach are admitted to a single department but formulate a program of study and research that draws on faculty and facilities in other areas of the university. Superior candidates may qualify for financial support in the form of teaching assistantships, graduate assistantships, research assistantships, scholarships, or university fellowships.

College of Business and Economics
James W. Schmutter, dean

The College of Business and Economics offers the master of science degree in economics, master of business administration, master of management science, master of science in management of technology and the doctor of philosophy degree in business and economics.

Graduate education in the College of Business and Economics distinguishes by emphasis between professional management training through the M.B.A., which generally, though not always, concludes at the master's level, and graduate pursuit of business and economics subjects in depth for research and/or teaching expertise through the doctoral and related M.S. programs.

There are two departments in the college: business and economics. Course descriptions can be found listed under accounting, business, economics, finance, law, management, and marketing in Section V; more information about the various degree programs appears below. The college publishes a brochure describing its graduate programs, which may be obtained by writing to the College of Business, Rauch Center, 621 Taylor Street, Bethlehem, Pa. 18015.
College of Education
Alden J. Moe, 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 Science. 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, reading specialists and supervisors, curriculum specialists and supervisors, specialists and supervisors in the education of mentally and emotionally disturbed children, teachers of preschool children (especially children with handicaps), teachers for the social restoration of potential delinquents, 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 567 students are involved in advanced study at the master's and doctoral levels during the 1994-95 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 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; one school, Centennial School, and one center the SMART Center. Within the department there are six program areas, each with its own coordinator: counseling psychology, educational leadership, educational technology, reading & teacher education, school psychology, and special education.

Centennial School. The College of Education operates the Centennial School—a laboratory facility for exceptional 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, special education, and reading.

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

College of Engineering and Applied Science
Harvey G. Stenger, dean

The College of Engineering and Applied Science offers the master of science, master of engineering, and doctor of philosophy degrees in each of its six academic departments and in interdisciplinary programs as well. Each department creates its own course, examination, and thesis or dissertation requirements within the framework of those established by the Graduate School. The departments in the college offering graduate degrees are chemical engineering, civil engineering, electrical engineering and computer science, industrial engineering, manufacturing systems engineering, mechanical engineering and mechanics, and materials science and engineering.

Graduate study in the College of Engineering and Applied Science is closely related to the college's extensive research activity, and all 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. This 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. All students in interdisciplinary degree programs are associated with specific academic departments.
Admission to Graduate Study

A graduate of an accredited college or university may be considered for admission to the Graduate School. The decision to admit a student ordinarily 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.

Applications for admission may be obtained by writing to the Graduate Admissions Office, 5 E. Packer Avenue, Lehigh University, Bethlehem, Pa. 18015.

An applicant may enter the graduate program as a student in one of two categories: regular or associate. Except for qualified Lehigh undergraduates, only those who have been admitted officially by the graduate admissions office either as regular or associate graduate students 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 the Graduate Admissions 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 Admission Test (GMAT).

Admission of a student to graduate standing is executed through the Office of Graduate Admissions. Credentials for admission to all 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 after these programs must be filed with 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.

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.

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-, C+, or B-; all other grades must be B or better. Students receiving a grade of C- or lower 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 already on file. Courses completed during a successful probationary period may count toward a graduate degree if they are part of an approved program.

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 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 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 graduate studies. 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 graduate admissions 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
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 Dean of Graduate Studies.

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 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 X 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 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 on 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 advisor 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 advisor to the Graduate School Office. Withdrawal after Registration day and during the first eleven 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 "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.
Graduation

**Degree registration.** A student must be registered in the semester in which the degree is conferred. A spring or summer registration will satisfy the registration requirement for the following Founder's Day degree, provided all work is completed before the first day of fall classes.

**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 on Founder's Day in October must file this form by September 1. Candidates for degrees to be conferred in January must file by December 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 be certain that they have completed all coursework for incompletes they may have received.
- Theses and dissertations must be cleared by the Graduate School office.
- All financial obligations must be cleared with the bursar.
- All library books on loan must be returned.
- Students must turn in their student identification cards at Christmas-Saucon Hall Annex.
- The interdepartmental clearance sheet must be completed. This form requires the signature of the student's department chairperson (except for the College of Education), and the facilities services office before it is submitted to the registrar at least three days prior to graduation.

Tuition

**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>Time Period</th>
<th>Refund Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to the start of the semester</td>
<td>100%</td>
</tr>
<tr>
<td>During first calendar week</td>
<td>80%</td>
</tr>
<tr>
<td>During second calendar week</td>
<td>70%</td>
</tr>
<tr>
<td>During third calendar week</td>
<td>60%</td>
</tr>
<tr>
<td>During fourth calendar week</td>
<td>50%</td>
</tr>
<tr>
<td>During fifth calendar week</td>
<td>40%</td>
</tr>
<tr>
<td>During sixth calendar week</td>
<td>30%</td>
</tr>
<tr>
<td>During seventh calendar week</td>
<td>20%</td>
</tr>
<tr>
<td>During eighth calendar week</td>
<td>10%</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 1995-96

<table>
<thead>
<tr>
<th>Service</th>
<th>per credit hour</th>
<th>per semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition</td>
<td>$740</td>
<td></td>
</tr>
<tr>
<td>Per course charge for audit</td>
<td>740</td>
<td></td>
</tr>
<tr>
<td>Tuition for enrollees in the Masters of Business Administration program and Management of Technology program</td>
<td>550</td>
<td></td>
</tr>
<tr>
<td>Tuition for enrollees in the College of Education and for full-time elementary and secondary teachers and administrators enrolled in the other three colleges</td>
<td>430 Maintenance of candidacy</td>
<td>740</td>
</tr>
<tr>
<td>Master's candidate registration fee</td>
<td>740</td>
<td></td>
</tr>
</tbody>
</table>

**Living accommodations.** The university maintains a graduate student housing complex in the Saucon Valley that has 112 living units. This complex, Saucon Village Apartments, provides units generally on a yearly lease basis. For the 1995-96 period beginning in September, the following are the monthly rents exclusive of utilities:

<table>
<thead>
<tr>
<th>Type</th>
<th>Rent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency apartment</td>
<td>$365</td>
</tr>
<tr>
<td>One-bedroom apartment</td>
<td>430</td>
</tr>
<tr>
<td>Small two-bedroom apartment</td>
<td>470</td>
</tr>
<tr>
<td>Two-bedroom apartment w/o AC</td>
<td>485</td>
</tr>
<tr>
<td>Two-bedroom apartment w/AC</td>
<td>495</td>
</tr>
<tr>
<td>Three-bedroom apartment</td>
<td>500</td>
</tr>
</tbody>
</table>

**Other Fees**

<table>
<thead>
<tr>
<th>Service</th>
<th>Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application fee (for graduate admission consideration)</td>
<td>$40</td>
</tr>
<tr>
<td>Graduate activities fee, per semester</td>
<td></td>
</tr>
<tr>
<td>Full-time students</td>
<td>12</td>
</tr>
<tr>
<td>Part-time students</td>
<td>6</td>
</tr>
<tr>
<td>Late registration (for completing registration after announced day)</td>
<td>50</td>
</tr>
<tr>
<td>Late application for degree</td>
<td>25</td>
</tr>
<tr>
<td>Late payment (after announced date)</td>
<td>50</td>
</tr>
<tr>
<td>Return check fine</td>
<td>20</td>
</tr>
<tr>
<td>Identification card (replacement)</td>
<td>10</td>
</tr>
<tr>
<td>Thesis, microfilming</td>
<td>25</td>
</tr>
<tr>
<td>Dissertation, microfilming</td>
<td>50</td>
</tr>
<tr>
<td>Placement fee, College of Education</td>
<td>25</td>
</tr>
<tr>
<td>Supervision fee, College of Education (per 3 credits)</td>
<td></td>
</tr>
<tr>
<td>Counselor intern</td>
<td>100</td>
</tr>
<tr>
<td>Counselor and school psychology clinic</td>
<td>100</td>
</tr>
<tr>
<td>Social restoration intern</td>
<td>225</td>
</tr>
<tr>
<td>Reading practicum</td>
<td>100</td>
</tr>
<tr>
<td>Administrative intern</td>
<td>225</td>
</tr>
<tr>
<td>Elementary and secondary intern</td>
<td>225</td>
</tr>
<tr>
<td>Special education intern</td>
<td>225</td>
</tr>
</tbody>
</table>
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 or by the Graduate School. 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. 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 and research assistantships.

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 graduate studies 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 tuition 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 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 major field;
- rank in the 85th percentile or higher on the Graduate Record Exam or other standardized test;
- 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 dean of graduate studies.

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 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 graduate school office, the office of the vice president of student affairs, the dean of students office, the university counseling service, and by career services.

Loans and work-study awards. Student may apply for the federally-funded Stafford and Perkins loans, Lehigh University Tuition Loans (UTL), 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 and a university application. Also required in the application process is the Financial Aid Transcript, which must be received from any (and all) post-secondary schools attended, whether or not you received aid. Funds cannot be disbursed without 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 you 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) is also available at participating lenders. A listing of student "rights and responsibilities" is printed in the section on undergraduate financial aid.

Degree Information
The following degrees are offered by the Graduate School: the master's degree, the doctor of philosophy, 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 normally be done in attendance at Lehigh University. With the approval of the dean of graduate studies, 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 Graduate School as soon as possible after 15 credit hours toward the degree have been completed. Approval of the program by the Graduate School 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 department, must be delivered to the Graduate School 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 Graduate School office.

A non-thesis option exists in certain departments in the College of Engineering. Students should check with their departments regarding that option.

Doctor of Philosophy
Time and registration requirements. A candidate for the doctor of philosophy degree is expected to devote at least three academic years to 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 minimum degree registration requirement of 72 or 48 credits is attained prior to formal admission to doctoral candidacy, continued registration of at least three credits per semester is necessary. Full-time student status must be certified on the graduate registration form.

After admission to doctoral candidacy, a student must maintain candidacy by registering at least two times each
calendar year (in each academic semester or in one academic semester and one summer session). 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 Graduate School for action by the graduate and research committee. The Graduate School 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 dean of graduate studies 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 dean of graduate studies for review by the university's graduate and research committee no later than two weeks before the degree is to be conferred. Two unbound copies must be delivered to the Graduate School office. One copy 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 Graduate School 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, (5) and 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 Admission 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.

Master of Business Administration

The Master of Business Administration (MBA) degree program is designed to provide candidates with conceptual, analytical, and operational skills that are involved in the decision-making processes connected with managing human, physical, and financial resources. The MBA curriculum provides a blend of strong theoretical foundation together with practical application in the areas of accounting, organizational, behavioral, economics, finance, the legal environment, management, marketing, and quantitative methods.

Education in the business professions requires an understanding of the various organizational functions and integrating these with internal and external aspects of the enterprise into the managerial process. The program encompasses generalized managerial competence, while permitting advanced study in such fields of specialization as finance, marketing, quantitative and behavioral facets of management, accountancy, economics, international trade and finance, and labor and industrial relations.

All candidates for entry into the MBA program are required to take the Graduate Management Admission Test (GMAT). Information concerning this test may be obtained at college and university counseling centers, or by contacting GMAT, Educational Testing Service, P.O. Box 6103, Princeton, N.J. 08541-6103.

Program prerequisites. Students entering the MBA program should have completed college-level coursework in principles of economics, calculus, and computer literacy. Although failure to complete these prerequisites will not necessarily result in denial of admission to the program, a student without them will be expected to complete the three prerequisites at Lehigh or elsewhere by the end of the first semester following matriculation into the program. If a student can demonstrate proficiency in a high-level programming language without formal coursework, he or she may petition to have the computer programming prerequisite waived.

The MBA curriculum. The minimum number of credit hours required for the MBA degree is thirty, normally consisting of ten courses. This minimum presumes that the prerequisites and foundation courses in the various functional fields were completed prior to entry into the program. If you have a bachelor's degree in business administration from an institution accredited by the American Assembly of Collegiate Schools of Business, you may reasonably expect to have fulfilled many of the foundation course requirements.

For each waiver granted, one credit hour of elective work is added to the minimum requirement of three elective courses. The number of credit hours to be added because of waivers is rounded up or down to the nearest multiple of three to determine the number of additional three-credit-hour courses you must take as a result of waiving core courses.

Core Courses

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<tr>
<th>Course</th>
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<tbody>
<tr>
<td>Acct 403</td>
<td>Financial Flows and Accounting Measurements</td>
</tr>
<tr>
<td>Econ 401</td>
<td>Basic Statistics for Business and Economics</td>
</tr>
<tr>
<td>Econ 409</td>
<td>Money, Banking, and Macroeconomic Analysis*</td>
</tr>
<tr>
<td>Law 404</td>
<td>Legal Environment of Management</td>
</tr>
<tr>
<td>Mgt 401</td>
<td>Quantitative Methods in Business and Economics</td>
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Advanced Integrative Courses

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<th>Course</th>
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<tbody>
<tr>
<td>Acct 413</td>
<td>Managerial Accounting and Decision-Making*</td>
</tr>
<tr>
<td>Econ 408</td>
<td>Price Theory and Applications**</td>
</tr>
<tr>
<td>Fin 411</td>
<td>Financial Management*</td>
</tr>
<tr>
<td>Mgt 413</td>
<td>Organizational Behavior and Management*</td>
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<tr>
<td>Mkt 413</td>
<td>Marketing Management*</td>
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Interdisciplinary Courses

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<th>Course</th>
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<tbody>
<tr>
<td>Acct 421</td>
<td>Information Systems for Managers**</td>
</tr>
<tr>
<td>Mgt 423</td>
<td>Operations Management***</td>
</tr>
<tr>
<td>Mgt 429</td>
<td>Managerial Policy and Decision-Making***</td>
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</tbody>
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*Waiver of any of these courses requires a B- or better in two undergraduate courses in the discipline.

** Waiver of Economics 408 requires completion of an undergraduate intermediate microeconomics course. (If you waive Eco 408, you must take Economics 421, Managerial Economics.)

*** These courses are required of all candidates and cannot be
Elective Courses. You must take three to six elective courses, depending on the number of core courses you are able to waive. These electives may include a maximum of two courses per discipline and up to six credit hours outside the College of Business and Economics (but within Lehigh University). All elective courses must be at the 400 level.

Class Scheduling. For the convenience of full-time and part-time students, most classes are scheduled in late afternoons and evenings. Part-time students may complete the entire program during late afternoons and evenings. To help you accelerate your completion of the program, many courses are offered during the two six-week summer session.

Master of Science
Degree in Business and Economics
The master of science degree is offered to students interested in pursuing graduate work in economics or in economics and business.

A minimum of thirty semester hours of coursework is required. At least eighteen of these hours must be taken in the College of Business and Economics. In addition, the student will be expected to pass comprehensive examinations in general economic theory and in one other field in the college.

To qualify for the master of science degree, the student must take the following courses in Economics, as part of his or her thirty semester hours of coursework:

- 408 Price Theory and Applications
- 415 Econometrics I
- 420 Advanced Macroeconomic Analysis
- 432 Advanced Microeconomic Analysis
- 456 Mathematical Economics

Master of Science
Degree in Management Science
This degree is available to students as an interdisciplinary degree with the Department of Industrial Engineering. Students are admitted and may enroll in either the College of Business and Economics or the Department of Industrial Engineering. The master of science in the management science program is directed toward integrating the scientific method with the functional aspects of organizations. By investigating the application of quantitative methodology and systems analysis in the context of such areas as accounting, applied economics, finance, marketing, production, and public service, the program helps to develop a meaningful analytical perspective of business problems.

This integration provides the student with a broader perspective of managerial decision making in private enterprise and/or public administration. Students who have had prior exposure as undergraduates to engineering, business, economics, mathematics, or the physical sciences and who desire a quantitatively oriented business program are ideal candidates.

Management science graduates may pursue careers as staff specialists or as line managers who must deal with the increasingly complex problems of industrial, commercial, and public service organizations.

At the completion of the degree requirements, the student will have acquired an excellent background in the various functional areas of business and economics. Included is a three-credit research project or practicum aimed at providing the student with professional exposure while still in a formal educational environment. Each student conducts an empirical investigation of an actual management problem and submits an individual written report.

Master of Science in Management of Technology
Lehigh's Master of Science program in Management of Technology (M.S. in MOT) equips scientists and engineers for general management responsibilities in technology-intensive firms and industries, and prepares them for such managerial responsibilities as:

- Creating or acquiring technical knowledge that can become the basis for new and improved products, process, and services
- Commercializing innovative products, processes, and services that embody new technical knowledge
- Generating profits from technical and commercial developments

Graduates will be equipped to participate in strategic and tactical decisions that are affected by technology, and be effective agents of change for improving the technology-management process.

More specific and complete details of the program are reflected on page 50. Applicants must submit a complete 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 Examination (GRE) or the Graduate Management Aptitude Test (GMAT). Complete applications must be received by June 15 to be considered for the Fall semester. A brochure describing the MOT program, an application for admission, and any additional information may be obtained by contacting either Alden S. Bean (director, Center for Innovation Management Studies, 610-758-3427), or Kathleen A. Trexler (Assistant Dean, College of Business and Economics, 610-758-3418) at Lehigh University, 621 Taylor Street, 37 Rauch Business Center, Bethlehem, Pa 18015.
**Doctor of Philosophy**

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 specialized study. Economic theory must be included as one of the major fields. Each student must take a research core of twelve hours and prepare for written and oral comprehensive examinations in the major fields. The chairperson of the doctoral committee will help to arrange a plan of study suitable for each student's program and to prepare the student to pass the examinations.

Major fields of specialization that are normally available include economic theory, international economics, labor economics, managerial economics, money and banking, finance (corporate, financial markets and institutions, investments), 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.

**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 adviser for a list of regulations and requirements governing their degree programs.

**Financial assistance.** The College of Education, because it does not offer many undergraduate courses, cannot 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 Graduate School.

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 administration, community counseling, elementary and secondary school counseling, reading, and social restoration. 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 eighteen credits of graduate work in education plus twelve credits of graduate work in an academic field. The academic fields that cooperate with the College of Education in offering this program include: classical languages, modern foreign languages, English, mathematics, economics, government, social relations, history, international relations, or 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 twelve to fifteen 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 administration, reading, 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.
Graduate Study for Engineering Professionals

All departments within the College of Engineering and Applied Science offer a cooperative program that allows an engineer working in industry to further his or her education while retaining a professional position. Students enrolled in this program may pursue an M.S., M.Eng., or Ph.D. at Lehigh while employed full-time, completing the course requirements for the degree in a period of time that does not greatly exceed what they would spend if they were full-time graduate students in residence at Lehigh.

A professional interested in participating in this program applies to the Graduate School through a participating department. (See course listing for each department for specific areas of research, courses available, and departmental requirements.) When accepted, he or she chooses the track best suited to his or her individual needs. Each track allows a student to obtain a master's degree, then, a highly motivated professional may pursue a doctoral degree if he or she chooses.

In any case, however, the residency requirements for the master's degree are fulfilled by spending two semesters at Lehigh as a resident graduate student. During the intervening semesters or summers, the student returns to the full-time, professional position. (It is best to spend a fall semester and spring semester on campus to allow maximum flexibility in course selection.)

The thesis or project required for the degree sought is decided upon through mutual consultation among the student, the adviser at Lehigh, and the supervisor in industry. The thesis or project work is begun during the student's first semester at Lehigh with the body of work performed when the student returns to his or her position in industry. Then, the thesis is completed when the student returns to Lehigh.

Each student chooses a faculty member at Lehigh who serves as academic adviser, helps the student select appropriate courses, and oversees the thesis or project work. The student also has a corporate adviser, preferably the person to whom the student reports, or a senior experienced member of the corporate staff. It is hoped that in many cases the interactions among faculty member, corporate adviser, and student/employee will form the basis for a continuing relationship between the university and industry that will allow significant and ongoing research areas to be addressed by a sequence of students seeking advanced degrees.

While enrolled in the program, the student remains an employee of the company or corporation and receives his or her salary as usual. (Lehigh considers that salary a matter to be arranged between the student and the employer.) Students are responsible for the full tuition due the university and are reimbursed by their employers according to company policy. Generally, this means that students must make satisfactory progress towards the degree sought and achieve acceptable grades in coursework.

Because the program requires additional work by faculty and staff, the company agrees to donate a sum equal to the university's tuition to the department in which the personnel are enrolled. In addition, companies agree to assist the department in meeting laboratory, computer, and other research costs that accrue during the student's research or project work.

The program is structured to be flexible enough to meet the needs of professional participants; the choice of approach will depend on the circumstances that pertain to particular industries and to the needs and interests of individual students.

Graduate School 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 Science; two from the College of Business and Economics; four from the College of Engineering and Applied Science; and two from the College of Education, plus four ex officio members and three non-voting student members, two graduate students and one undergraduate.

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 Stephen P. Link, '85, M.B.A. '91. The committee will provide leadership 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. In addition, four graduate student council members serve on the dean's advisory committee in order to provide a liaison between the dean of graduate studies and the graduate student council.

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 applied mathematics, applied social research, biology, clinical chemistry, design management science, manufacturing systems engineering, molecular bioscience and biotechnology, physiological chemistry, and polymer science and engineering.

In addition, Lehigh's 29 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 area 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.

Applied Mathematics
Lehigh University offers interdisciplinary programs leading to the degrees of Master of Science and Doctor of Philosophy in Applied Mathematics.

Students may participate in the program either through the Division of Engineering Mathematics within the Department of Mechanical Engineering and Mechanics or through the Division of Applied Mathematics and Statistics within the Department of Mathematics.

The Ph.D. program is aimed at students with a background in mathematics, the sciences, or engineering who wish to obtain a thorough training and to develop their research ability in applied mathematics. Students will be admitted to one of the two divisions according to background and interests.

Seminar series in engineering science and applied mathematics in which visitors, faculty and students discuss current research, are available.

Admission Procedure. Applications are invited from students with backgrounds in engineering, mathematics or the sciences.

A complete application should include undergraduate and graduate transcripts, the aptitude part of the GRE, and at least two letters of recommendation. Foreign students must submit evidence of proficiency in English.

All applications are reviewed by the Department of Mathematics and Department of Mechanical Engineering and Mechanics. Students whose area of specialization is Applied Mathematics must register in one of the two departments and specify on their application the department of their choice. For application forms and information, write:

Prof. Philip A. Blythe, Head
Division of Engineering Mathematics
Packard Laboratory #19
Lehigh University
Bethlehem, PA 18015 Tel. (610) 758-3782

Prof. Gregory T. McAllister, Head
Division of Applied Mathematics & Statistics
Christmas-Saucon Hall #14
Lehigh University
Bethlehem, PA 18015 Tel. (610) 758-3730

Lehigh University
Alumni Memorial Building 27
Chairman of Coordinating Committee
Applied Mathematics Program
Bethlehem, PA 18015-9988

Financial Aid. Teaching assistantships are offered by both departments, and university fellowships and scholarships are offered by the Graduate School. Research assistantships are sponsored by governmental agencies and industry.

M.S. Program. A master's program must include at least thirty semester hours of courses.

Students in the Mathematics Department must pass a comprehensive examination. They may replace up to six hours of course work with a thesis. Research credits are obtained by registering in MATH 490—Mathematics Thesis.

Students registered in the ME/Mechanics Department must submit a thesis, which may replace up to six hours of course work. No comprehensive examination is required. Research credits are obtained by registering in EMA 490—Engineering Mathematics Thesis.

Ph.D. Program. The master's degree is not a requirement for the Ph.D.

A candidate entering at the bachelor's level must satisfy only the course requirements of the master's degree in the division in which he/she is enrolled. The candidate's advisor will recommend courses that help in preparing for the qualifying exams. Any additional course requirements will be determined by the student's dissertation committee. Students registered in the ME/Mechanics department obtain research credits by registering in EMA 499—Engineering Mathematics Dissertation.

Students registered in the Mathematics Department must satisfy the foreign language requirement. They may obtain
research credits by registering in MATH 499—Mathematics Dissertation.

It is recommended that the qualifying examination be taken at the beginning of the fourth semester for students entering at the bachelor's level and at the beginning of the second semester for students entering with a master's degree.

The examination consists of three written tests. One is in analytical methods, one is on numerical methods or discrete mathematics, and one is on a topic from the physical or mathematical sciences as approved by the candidate's division.

**Applied Social Research**

The applied social research program leads to the Ph.D. degree. The objective is to train specialists to consult on and to conduct applied social science research involving individuals, groups and social settings in business and industry, educational organizations, medical and human services programs, and governmental planning and policy making agencies. The interdisciplinary program is sponsored by the departments of psychology, social relations, and government in the College of Arts and Science, by the College of Business and Economics, by the College of Education and by the Center for Social Research. The training program includes relevant research techniques and strategies from the disciplines these departments and colleges represent.

In recent decades specialized methods have been developed for conducting research involving economic projections, market research, environmental and social impact analyses, experimental research, and program evaluation and to gather data for governmental and private planning and policy analyses. The methods have common features such as research planning, design and implementation, measurement design, sampling procedures, statistical analyses, computer applications and data management, interpretation and evaluation of results, and decision making based on the results.

The aim of the applied social research program is to develop methodological generalists who are knowledgeable in and have experience with the rather wide variety of methods required to conduct research in business, educational, social service, governmental and planning organizations. In contrast to academic settings where the tendency is to become increasingly specialized, the need in applied settings is for expertise in solving problems requiring a variety of social science research skills. In addition to a broad methodological background, the program provides the student with experience in conceptualizing, designing, implementing, interpreting, and communicating applied research.

**Program requirements.** Entrance requirements are a master's degree in social science, psychology, education or business, or in a field deemed by the coordinating committee to provide relevant background and sufficient quantitative skills to give some assurance of success in the program. A program of study and research will include courses in statistics, research design, measurement design, computer methods and research applications. A qualifying examination is given after 18-20 credits of work. Advanced courses, a research internship and a dissertation complete the requirements. Specifics of a student's program are to be worked out with a faculty adviser and depend on the student's past experience, educational and occupational goals.

**Financial aid.** Research assistantships, teaching assistantships, and fellowships or scholarships are available.

**Application for admission.** Requests for further information and for applications for admission should be directed to: Applied Social Research Ph.D. Program Coordinating Committee, Center for Social Research, Lehigh University, 516-520 Brodhead Ave., Bethlehem, Pa. 18015.

**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 physiological 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.
Design
The Master of Science in Design Program is built upon an undergraduate engineering degree. It is anticipated that with time similar programs will develop for students with degrees from undergraduate arts or business programs. The curriculum is technological in nature, emphasizing design practice, design history, and design communication. It also focuses on issues related to aesthetics, business communication, management of people and technology, mathematics and modeling, manufacturing and manufacturing methods. A key component of the Design program is the Design Studio.

The Studio (6 credit hours) affords students and faculty the opportunity to collaborate on design related problems. The studio experience, which is the equivalent of a six-credit thesis, is modeled after the design studio concepts used by the Department of Art and Architecture. Students in this program are expected to provide designs in response to problem/need statements and to defend the solutions both in writing and orally. Faculty feedback is provided to students relative to the design and the effectiveness of the written and oral presentation. The critiques are offered by the “Design Faculty” from the Colleges of Engineering & Applied Science, Business and Economics, and Arts and Sciences. As part of this process, faculty discuss the pros and cons of the specific design, as well as the design process or processes used for producing the designs. These discussions are an ongoing part of the design studio and afford students the opportunity to reflect on the design process and how it should be executed in real world situations. As appropriate and as needed, personnel from industry and government are asked to participate in the review/critique process. Regular design meetings and seminars are used to provide input to this process and to provide continuity for the students over the course of their studio experience.

Additional Courses which make up the 30 credit hour curriculum include:

- **MSE 423**  Product Design & Analysis  3  Provides modeling and math skills
- **MSE 431**  Technological Innovation  3  Provides management/business skills in Manufacturing Organization
- **MSE 427**  Production Systems  3  Provides manufacturing skills
- **MAT 458**  Design  3  Provides materials application and materials processing skills
- **ART 395**  3  Provides rendering/industrial design skills

Electives  9  To be selected in consultations with an advisory committee

For further information, contact Professor Richard Roberts, program director, 200 West Packer Avenue, Bethlehem, PA 18015, (610) 758-3848, fax (610) 758-6527.

Management of Technology
Lehigh's Master of Science Program in Management of Technology (M.S. in MOT) equips scientists and engineers for general management responsibilities in technology-intensive firms and industries. The program prepares graduates for managerial responsibilities of three kinds:

- Creating or acquiring the technical knowledge that can become the basis for new and improved products, processes and services
- Commercializing innovative products, processes and services that embody new technical knowledge
- Capturing profits from technical and commercial developments

Graduates will be equipped to:

- Participate in strategic and tactical decisions that are affected by technology
- Be effective agents of change for improving the technology-management process

Program requirements. The program consists of 33 hours of required course credits, nine hours of electives and a three hour master's thesis for a total of 45 credits. There are three options for completing degree requirements:

Full-Time Option: A 12-month program (three semesters) requiring 15 credit hours per semester including the summer. Students should define their thesis project options by the time of admission. Permission of the Program Director is required.

Released-Time Option: A 21-month program (five semesters) requiring the student to be "released" for 3-6 hours per week during normal afternoon working hours to participate in the program.

Part-Time Option: A three-year program (nine semesters) requiring two courses per semester during the academic year and one course during each summer session.

Curriculum. Foundation courses establish a solid base of knowledge about the economic and historical importance of technology to industry and society and build competence in the use of financial and accounting tools to support technology-management decision-making. These courses give special attention to the issues and problems encountered by technology managers and to the distinctive challenges of supervising and leading technical professionals.

- Technology and Economic Analysis
- History of Industrial Technology
- Managerial Finance
- Cost Management and Accounting
- Managing and Leading Technical Professionals
Functional Core courses prepare students to manage and lead cross-functional technical projects by developing management and technology skills and by studying the management and technology responsibilities associated with other major functions encountered in most technology-intensive industrial firms. These courses emphasize both the strategic concepts and the operational skills associated with technology management in each functional area.

- RD&E Project Management
- Information Technology & Operations Management
- R&D Management

Integrative courses emphasize the formulation and implementation of overall technology strategies for companies ranging from individual businesses to large, complex firms. Integrative courses also provide an understanding of the roles played by scientific and technical institutions outside the firm, including government regulatory and standard-setting organizations, in the technological innovation process.

- Science and Technology Policies and Institutions
- Science, Technology and Competitive Strategy

Elective courses allow students to pursue special interests. In addition to a menu of elective courses within the MOT program, selected technical courses offered by other Lehigh departments may also be taken as electives, with the approval of the Program Director.

- Total Quality Management
- Management of Information Technology
- Science, Technology and International Business
- Analysis of Emerging Technologies
- New Product Planning and Development
- Diffusion and Implementation of Technology

Admission

The MOT program is intended for students with undergraduate degrees in science or engineering and at least two years of industrial experience. Students with undergraduate degrees in other fields will be considered based on employers' recommendations and other qualifications.

Applicants must submit a complete application, including a personal statement, transcripts from all undergraduate institutions, two letters of recommendation, a personal essay, and test scores (GRE or GMAT). Incomplete applications will not be considered. Complete applications must be received by June 15 to be considered for the Fall semester.

Inquiries

For a brochure describing the MOT program, an application for admission, or any additional information, please contact: Alden A. Bean, director, Center for Innovation Management Studies, (610) 758-3427, or Kathleen A. Trexler, Assistant Director, Center for Innovation Management Studies, (610) 758-3417, Lehigh University, 621 Taylor Street, Suite 37 Rauch Business Center, Bethlehem, PA 18015.

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 institutes. The MOT program will draw upon this network of industrial, government, and academic colleagues for guest lecturers and seminar speakers throughout the program.

Management Science

The industrial engineering department, in conjunction with the department of management and marketing, offers an interdisciplinary degree in management science. The management science program is directed toward integrating the scientific method with the functional aspects of organizations by investigating the application of quantitative methodology and systems analysis in the context of such functional areas as accounting, finance, marketing, and production. This integration provides the student with a broader perspective toward managerial decision making in private enterprise and public administration.

Undergraduates with a background in engineering, business, economics, mathematics, or the physical sciences who want a professional career as a staff specialist in management science are appropriate candidates. In addition, those candidates who intend to seek line manager positions find the management science background advantageous in dealing with the complex problems of industrial, commercial, and public service organizations.

The candidate is assumed to have acquired basic competence in the areas of accounting, marketing, corporate finance, production, data processing, microeconomics, linear algebra, calculus, statistics, and introductory operations research. The minimum program consists of thirty hours.

Required coursework

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>IE 418</td>
<td>Simulation</td>
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<tr>
<td>Mgt 321, IE 334</td>
<td>Organizational Behavior Workshop or</td>
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<tr>
<td>Mgt 413</td>
<td>Organization Planning and Control or</td>
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<td></td>
<td>Organization Behavior and Management</td>
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<tr>
<td>Eco 421</td>
<td>Managerial Economics</td>
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<tr>
<td>IE (Mgt) 430</td>
<td>Management Science Project</td>
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</tbody>
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The student must complete nine hours of quantitative methods, six hours selected from a functional area, and three hours from a list of electives.

Sample program

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<tr>
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<tbody>
<tr>
<td>IE 418</td>
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<td>Management Science Program</td>
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<tr>
<td>Eco 421</td>
<td>Managerial Economics</td>
</tr>
<tr>
<td>IE 316</td>
<td>Advanced Operations Research Techniques</td>
</tr>
<tr>
<td>IE 417</td>
<td>Mathematical Programming</td>
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</tbody>
</table>
Eco 455  Econometric Models
IE 419  Sequencing and Scheduling
Fin 430  Financial Management
Fin 431  Advanced Investment Analysis and Portfolio Management

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 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 a requirement), or a two-year part-time program for working engineers within commuting distance of campus. Courses in the part-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  Managing the Manufacturing Life Cycle (3)
MSE 423  Product Design/Analysis (3)
MSE 427  Production Systems (3)
+ one or two electives

Summer session (ten weeks)
One week 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 their Master's degree.

MSE 451. Manufacturing Systems Engineering Project (3)

OR

MSE 490. Manufacturing Systems Engineering Thesis (6)

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  Technological Innovation in the Manufacturing Organization (3)
MSE 433  Technology and the Factory of the Future (3)
+ one or two electives

PART-TIME OPTION

First Spring semester (odd years)
MSE 421  Managing the Manufacturing Life Cycle (3)
MSE 423  Product Design/Analysis (3)

First Fall semester
MSE 425  Production Planning & Resource Allocation (3)
MSE 427  Production Systems (3)

Second Spring semester
Elective Courses

Second Fall semester (even years)
MSE 431  Technological Innovation in the Manufacturing Organization (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. There are weekly seminars, specially designed tutorials on simulation, injection molding, and current topics etc., industry tours, and meetings with executives from industry at which attendance is expected.

Elective courses (6 or 9 credit hours): In order to complete their thirty credit hour minimum, students are required to take three approved elective courses unless they register for a thesis (6 credit hours) in this 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 ability to communicate and work in teams, as well as a team approach to projects which foster learning.

**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 their individual backgrounds and interests.
— All candidates must follow admission procedures and standards established by Lehigh University’s Graduate School.

**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 of $2,500 for 1996. 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 J1M1@Lehigh.edu.

**Molecular Bioscience and Biotechnology**
This interdisciplinary program leads to the degree of Master of Science in Molecular Bioscience 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 from this program into Ph.D. programs in Molecular Biology, Biochemistry, or Chemical Engineering.

The degree requires completion of thirty credits, eighteen of which must be at the 400 level. The required core courses, representing eighteen of the thirty 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 495 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 twelve credits must be drawn from the following approved 400 level courses:

- BioS 415; BioS 450; BioS 461; BioS 462
- 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; Chm 476

no more than 6 credits from the following 400 level approved lab courses:
- BioS 463; BioS 464; ChE 446; BioS 479; Chm 480

no more than 6 credits from the following 400 level approved seminar courses:
- BioS 406; BioS 466; ChE 448; Chm 435; Chm 477

a minimum of 3 credits of the following:
- BioS 407; ChE 480; ChE 481; Chm 421

All students must (a) register for 6 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, Iacocca Hall, 111 Research Dr., Lehigh University, Bethlehem, PA 18015.

**Physiological Chemistry**
The graduate program in physiological 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: nuclear medicine, medicinal chemistry, chemical and experimental parasitology, invertebrate pathobiology, comparative immunology, and chemical physiology. 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 303 Nuclear and Radiochemistry (3)
- Chm 336 Clinical Chemistry (3)
- Chm 371 Elements of Biochemistry I (3)
- Chm 423 Bio-organic Chemistry (3)
- Chm 424 Medicinal and Pharmaceutical Chemistry (3)
- Chm 435 Advanced Topics in Clinical Chemistry (3)
Polymer Science and Engineering

Lehigh has a diverse group of faculty members with strong, primary interest in polymer science and engineering. In order to provide better opportunities for courses and research in this interdisciplinary field, activities are coordinated through the Center for Polymer Science and Engineering (CPSE), and its academic polymer education committee. Polymer faculty from traditional departments of chemical engineering, chemistry, and materials science and engineering, physics, and mechanical engineering and mechanics, are participants of the CPSE.

There are two ways in which qualified graduate students, with degrees in the above or related fields, may participate. They may pursue graduate studies within an appropriate department. Departmental procedures must be followed for the degree sought. The student’s adviser may be in that department, or in another department, or research center. In this case, the student receives a normal departmental degree, with emphasis in polymer courses and research.

Alternatively, students may elect to pursue studies toward an interdisciplinary M.S. or Ph.D. degree in polymer science and engineering. The procedures for this latter case are summarized as follows.

M.S. in polymer science and engineering.

For the M.S., the student’s program must include: not less than thirty credits of graduate work; not less than eighteen credits of 400 level course work, and not less than eighteen credits of course work in the major, of which fifteen must be at the 400 level. The program must include six course credits in the student’s admitting department, 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:

- ChE (Chm) 388 Synthesis and Characterization Lab (3)
- ChE (Chm) 393; Physical Polymer Science (3)
- Mat 343
- ChE (Chm) 394 Organic Polymer Science (3)
- Research (6)

Three 400 level polymer courses to be selected from the following list (list may vary slightly from year to year):

- Mat 409 Fibers (3)
- ChE 428 Polymer Physics (3)
- Phy 472 Emulsion Polymers (3)
- ChE (Chm) 483 Engineering Behavior of Polymers (3)
- (Chm/Mat) 482 Polymer Blends and Composites (3)
- ChE (Chm/Mat) 485 Polymer Processing (3)
- Chm 489 Organic Polymer Science II (3)
- Chm 491 Physical Chemistry of Organic Polymer Coatings (3)
- ChE (Chm) 492 Topics in Polymer Science (3)
- Chm 493 Organic Chemistry of Organic Polymer Coatings (3)
- ChE (Chm) 496 Polymer Interfaces (3)
- ChE (Chm) 400 Chemical Engineering Thermodynamics (3)
- Chm (ChE) 445 Elements of Physical Chemistry (4)
The BioProcessing Institute coordinates the education and institutes focus of the research of this institute is on the processing of faculty members. Frequently, centers relate to the broad and research based on the expertise and capabilities of a group activities of academic departments and represent scholarship are generally interdisciplinary and complement the scholarly Research Centers 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.

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.

BioProcessing Institute

The BioProcessing Institute coordinates the education and research activity in the bioprocessing area of the Chemical Engineering Department at Lehigh University. The main focus of the research of this institute is on the processing problems related to the manufacture of products of interest to the biotechnology industries.

Research interests. The research thrusts of the institute include: fundamentals kinetics of microbial, mammalian and plant cell and enzyme systems; design and scale-up of bioreactor and bioseparation systems; modeling and control of bioreactor and bioseparation systems; development of instrumentation for the on-line monitoring of biological unit operations; and development of novel separation and purification schemes for recovery of biologically active macromolecules, antigens, and antibodies.

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 2DFT IHNMR; permissive effects in chromatographic separations; effect of cross-linking on biological activity; kinetics of enzyme production by cellulosolytic fungi/actinomycetes.

The research is conducted in Building A, Mountaintop Campus where the laboratories for the Department of Molecular Biology and Biochemistry research group, the Department of Chemical Engineering, the Emulsion Polymers Institute, and the Chemical Process Modeling and Control Center are also 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 BioProcessing Institute presently occupies 9000 square feet of laboratory space in the C wing of Building A of the Mountaintop Campus. The institute is equipped with an array of pilot-scale, computer-controlled bioreactors, monitored and controlled by IBM-PC's or 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 UTT Quadrupole Mass Spectrometer, BioChem Technology Fluorometer System, and a Digilab/Bio-Rad FTS 60 FTIR Spectrophotometer. Pilot-scale separations capability is being developed and currently includes a Millipore Pellicon Unit, and Sharples centrifuges and large-scale chromatography.

The fermentation and separations facilities are supported by analytical equipment and facilities including UV/visible spectrometers, isocratic and gradient HPLCs with refractive index and variable wavelength UV/visible detectors, gas chromatographs with FID and TCD detectors, YSI glucose analyzer, Branson cell sonifier, incubator/shakers, laminar flow hood, microscopes, etc.

Mammalian cell cultivation is conducted in a recently constructed class 1000 laboratory equipped with CO2 incubators, vertical laminar flow hoods, a Bellco roller bottle apparatus, Millipore Milli-Q purification system, inverted microscope, etc.

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

For more information, write to Janice A. Phillips, Director, BioProcessing Institute, Lehigh University, 111 Research Drive, Bethlehem, PA 18015.

Building and Architectural Technology Institute

BATI is concerned with the entire scope of the built urban environment, the social, and the cultural aspects of building technology. BATI researchers and faculty carry out border-crossing 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. BATI has as its goal both the enhancement of academic knowledge through academic research and the practical solution of current physical problems through applied research.

BATI 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. 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.

Study 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 associates from 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 10 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.
International Center for Democracy and Social Change

The International Center for Democracy and Social Change was established at Lehigh University in 1994. The core purpose of the Center is to develop a new, innovative teaching and research program in "democracy and social change" in international affairs, broadly defined to include both national (including the USA) and systemic dimensions.

This interdisciplinary program will address the task of educating students and promoting faculty research in understanding and managing critical changes in global society within the parameters of political democracy. The program is centrally involved in Lehigh's traditional educational mission of preparing future leaders both at home and abroad.

In addition to developing this core program, the Center will involve itself in three key aspects of international studies at the University. Specifically, the Center will undertake the following responsibilities:

1. To promote the internationalization of the academic curriculum throughout the College of Arts and Sciences.
2. To coordinate and strengthen area studies and multicultural programs, e.g., Asian American Studies, Asian Studies, Latin American Studies, and Russian Studies.
3. To cooperate with related departments, programs, and offices to enhance the overall international dimension at the University.

For more information, write to Professor Raymond F. Wylie, Director, Lehigh University, Maginnes Hall, 9 West Packer Ave., Bethlehem, PA., 18015; or call (610) 758-4745; fax (610) 974-2840; Email RFW1@lehigh.edu.

Center for Manufacturing Systems Engineering

The Center for Manufacturing Systems Engineering aims to catalyze, coordinate, develop and focus university activities associated with manufacturing. The Center is a focal point for manufacturing-related activities involving graduate education and research. It facilitates the development of knowledge of manufacturing sciences, systems and technologies and promotes the transfer of this knowledge to industry for practical application. The Center uses close ties with industry to ensure that classroom instruction is current, and that research goals are compatible with the long-range needs of industry. It is essential to maintain free flow of ideas and technology transfer both from research laboratories into industry, and from industry into the classroom. The Center works with an Industrial Advisory Board comprised of member firms in order to accomplish these goals.

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 or thesis studies.
3. Technology transfer to sustain the free flows of knowledge from the research laboratories out to industrial applications, and in the reverse direction 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.

Representatives appointed by subscribing member firms attend twice yearly meetings of the Industrial Advisory Board (IAB), and enjoy opportunities to serve on committees advising on research priorities, funding allocations, curriculum development, technology transfer (Conferences, clinics, seminars, plant visits and workshops), student recruiting and hiring. The Center manages a database comprising faculty research interests, the research priorities and needs of member firms and matches names of engineering contact points in industry.

Research activity. It is a basic thesis that "manufacturing" consists of any activity whereby materials and information are transformed into goods or services for the satisfaction of human needs; furthermore it is the purpose of manufacturing systems to generate wealth. The components of a manufacturing system can be enumerated simply as consisting of materials, processes, equipment, facilities, logistics and people. A manufacturing system is viewed as a complete system which embraces all the activities involved in developing an idea from concept out to the realization of a product (or service) which generates customer satisfaction and revenues, through to end-of-life. Manufacturing systems engineering involves the study, research and development of knowledge of the interactions between the various components as they are combined to generate products with revenues for the sponsoring enterprises and prosperity for the associated communities and stakeholders.

The Center supports research in manufacturing systems engineering by means of grants to faculty, and support of research assistants; students in the MS in MSE Program are also encouraged to undertake research of interest either to their employers, or to industry in general. Selection of appropriate research topics is done in consultation with the members of an Industrial Advisory Board. A current focus of 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. Thick film hybrid manufacturing and other processes are being set up in the Microelectronics Manufacturing Laboratory assisted by grants from the AT&T Foundation and equipment from the IBM Corporation. The purpose of the 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 out 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 commenced recently on applications of 3-D Lithography in rapid prototyping. There are additional activities examining impacts of Total Quality and ISO 9000. Some specific current projects include - the fundamental understanding of Die Attach materials and processes and correlation with the manufacturing processes, Real Time machine control operating systems, implementing a manufacturing floor control and quality assurance system in a small manufacturing organization, development of a comprehensive manufacturing database and taxonomy, applications of neural networks, Agile Manufacturing and User Friendly Packaging Design Systems. 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 the 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.

Educational opportunities. A predominant CMSE activity is a cross-disciplinary graduate program leading to an MS in MSE degree in the College of Engineering and Applied Sciences. This program includes courses delivered by faculty from the College of Business and Economics, it commenced in 1984 as result of a major initiation grant from the IBM Corporation. Since inception over 312 students have passed through this integrated offering which comprises several notable features including teaming activities and courses taught by members of several different departments.

The Center also administers and is closely associated with the interdisciplinary graduate degree program in design. A partial-release program utilizing the same "managed" curriculum is available for employees of Lehigh Valley and neighboring industries, there are separate classes requiring four semesters of one evening and one day per week attendance plus an industrial research project.

Admission to educational programs administered in association with the Center is achieved by application through the Graduate School 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. The Center may, or may not, choose to be associated with the support of the research goals of such doctoral candidates.

For more information, write to: Keith M. Gardiner, Director, Center for Manufacturing Systems Engineering, H.S. Mohler Laboratory, Lehigh University, 200 W. Packer Avenue, Bethlehem, Pa. 18015, or call (610) 758-5157.

Center for Molecular Bioscience and Biotechnology

The Center for Molecular Bioscience and Biotechnology represents part of Lehigh University's commitment to an environment that promotes interdisciplinary research and training opportunities. By bringing together faculty, graduate students, and support staff with backgrounds in biochemistry, biochemical engineering, molecular biology, and the neurosciences in a single state-of-the-art laboratory facility, the center fosters collaborations among faculty, students, biotechnology companies, and health care providers that will lead to advances in product development, production techniques, diagnostic tools, and treatment delivery systems.

The center is one of the best-equipped basic and applied biotechnology facilities in the country. Consisting of over 45,000 square ft. of laboratory and office space, it contains core facilities (for example, for DNA synthesis, digital imaging, chromatography, cell culture, centrifugation, controlled environments, gamma and scintillation counting, flow cytometry, etc.), individual biochemistry and molecular biology labs, and a pilot plant with a range of fermentation process capabilities.

The financial mainstay of the center is standard contract research from government funding agencies and private companies. In addition, the CMBB Liaison Program encourages private companies to maintain strong ties with the university by supporting, through a single program, proprietary research and nonproprietary fundamental research of general interest. Through the program, member companies gain access to university resources, stay in touch with the current basic research, and have the opportunity to work directly with faculty and students on projects of mutual interest. Center faculty and their students benefit by keeping aware of the latest developments and needs of the private sector.

Research activities. Current interests within each of the cognate disciplines are:

Biochemistry: Structure and function of glycoproteins and proteoglycans in normal and diseased tissues, lysosomal enzyme structure and function, eukaryotic DNA structure and nucleosome formation, the use of porphyrins for the diagnosis and treatment of malignancies, preparation of radiopharmaceuticals with high target-tissue specificity, synthesis of therapeutic drug candidates, development of non-isotopic immunoassays, and kinetic and thermodynamic aspects of protein binding surfaces.

Biochemical Engineering: Research interests encompass several aspects of bioprocessing with emphasis on bioprocesses using adsorption and aqueous two phase systems, chromatographic modeling, bioreactor instrumentation and control, and the development of strategies for culturing mammalian and microbial cells. Molecular Biology: Structural/functional analysis of fundamental cytoskeletal filaments, tissue-specific gene expression and protein function during development, plant cell molecular genetics, heterologous gene expression, RNA processing and ribonucleoprotein transport, and translation control, diagnosis...
The Center for Polymer Science and Engineering (CPSE) was formally established at Lehigh University in July 1988. The 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; and 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, physical polymer science and organic polymer science, engineering behavior of polymers, rheology, polymer processing, emulsion polymers, biopolymers, 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: Surface/interfacial aspects of polymer colloids, adhesion, and polymer blends and composites; polymerization mechanisms and kinetics; polymerization reactors modeling and control; structure/properties relationship of interpenetrating polymer networks; macromolecular chemistry of biopolymers and coal; polymer coatings for corrosion protection, microelectronic packaging.

Research facilities. The following research instrumentation are available for the Center for Polymer Science and Engineering: X-Ray Photoelectric Spectroscopy (ESCA), Scanning Auger Electron Spectroscopy, Laser Raman Spectroscopy, Mossbauer Spectroscopy, Nuclear Magnetic Resonance Spectroscopy of both solids and solutions (NMR) (3 instruments; 90 MHz, 300 MHz and 500 MHz), Fourier Transform Infrared Spectroscopy (FTIR) (both conventional and photo-acoustic), a variety of advanced transmission and scanning electron microscopes, several calorimetry devices, instruments for rheological studies (including a Rheometrics RDA® and Bohlin Rheometer), particle sizing instruments (Coulter N4M, Joyce-Loebl Disc Centrifuge, Capillary Hydrodynamic Fractionation, and Hydrodynamic Chromatography), Gel Permeation and Gas Chromatography units, Electrophoretic Mobility 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-Aasser, Director; Center for Polymer Science and Engineering, Iacocca Hall, Room D330, Lehigh University, 111 Research Drive, Bethlehem, PA 18015; (610) 758-3590.

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, marketing, and political science. 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; design of housing for the older adult, 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 child rearing practices on children's development of competence.

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.

Educational opportunities. Master's and doctoral-level degrees are offered through the departments with which CSR cooperates. An interdisciplinary doctoral program in applied social research is offered jointly by the departments of psychology, government and sociology/anthropology in the College of Arts and Sciences, by the College of Business and Economics, by the College of Education, and by the Center for Social Research. This program emphasizes training in research methodology relevant in nonacademic settings (see description under Interdisciplinary Graduate 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
Mission: 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 compliance with government regulation while continuing to educate engineers in the techniques that the Center has and continues to develop.

Background: 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 as has the National Science Foundation. The involvement of the National Science Foundation has and continues to be an important element in the success of the Center’s efforts since the National Science Foundation provides critical annual evaluations of the Center to ensure both leadership and relevance in the technological developments that 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 conducting 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. They are invited very frequently to present plenary lectures in international conferences, industrial company meetings and various universities. They organize and chair national and international conferences and symposia. They also serve as consultants to a variety of industries seeking their advice on leading technological developments in process modeling and control.

**Facilities:** The Center is located at the Iacocca Hall of the Mountain 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 Engineering Process Control, III) Nonlinear Identification and Model Predictive Control, and IV) Engineering Interface Between 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 with 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 Engineering Process Control:** In meeting the goal of the continuous improvement of chemical processes, a key strategy is the systematic identification and elimination of special causes of variation. This focus area is devoted to developing statistical methods that can work in harmony with engineering process control methods toward the goal of process improvement. By exploiting the nature of as well as the data available from continuous processes, we have developed methods that advance statistical process control 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 on-set of a disturbance and the possible isolation of its character and its point of origin. Most of the application so far have been in the operation of continues 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 A on Tendency Modeling of Batch processes, these multivariate Statistical Process Control tools can be effectively applied to the operation of batch processes.

Parallel statistical tools are presently considered for the monitoring of the effectiveness of the control structure active in a plant. This aims to provide an early detection signal for the need to re-tune the controller and possibly re-identify the process model used in model-based control strategies and model-based inferential measurements.

III. Process Identification and Model-based Control: Recent efforts to increase the process productivity and product quality of petroleum, chemical and pharmaceutical processes have increased the importance of process nonlinearities and process constraints as well as the interactions between several variables and units in the controller design. The traditional unconstrained univariate linear controller, like the PID type, is not well suited to handle these challenges. This realization has lead to the development of various multivariable linear and nonlinear model-based control designs in the past decade. The general aims of the present research efforts include the development of process models and model-based control strategies that handle complex industrial problems. One of the specific objectives is to develop an effective Multivariable Nonlinear Model-based Predictive Control (MNMPC) technology. The controller design utilizes a nonlinear model derived from either a detailed first principles' model (knowledge driven) or based on the input-output data obtained from the actual process (data driven) or preferably a model driven by both process knowledge and data (hybrid model). In order to be able to develop process models from existing plant data obtained under closed-loop conditions, a parallel objective has been recently established in closed-loop identification. This type of identification results in a control-relevant process model yielding a high performance model-based controller. The aim of the effort is to adapt and further develop closed-loop identification methods applied to challenging chemical process examples (e.g., Amoco FCCU, Tennessee Eastman plant simulation) and obtain process models suitable for the design of linear or nonlinear model predictive controllers.

IV. Engineering Interface Between Process Design and Control: Several research projects explore two important aspects of process design and process control: (1) trade-offs between steady-state economics and dynamic controllability, and (2) plant-wide control. One completed project studied a number of coupled reactor/column processes, outlining design procedures and developing effective control structures. The processes varied from a simple rectifier/reactor binary system to a four-component reactor-stripper, two-column process with recycle. The use of steady-state sensitivity analysis to screen plant-wide control structures was demonstrated. Another project explores the effects of design parameters on controllability. The goal is to develop methods and heuristics that can aid in selecting a more controllable plant. For example, large reactors and impure recycle streams have inherent dynamic advantages.

A methodology has been developed to quantitatively incorporate dynamic controllability into the economics of steady-state design. It is simple and rapid enough to permit screening of a large number of alternative flow-sheets and design parameters at the conceptual design stage. Product quality variability is explicitly incorporated into the procedure by determining the time periods in which off-specification product is produced.

Other projects include (1) design and control of chemical plants that must undergo frequent transitions from one product to another, and (2) design and control of plants with recycle streams in which purging of inert components is required to prevent buildup.

For more information, contact Christos Georgakis, Director, Center for Chemical Process Modeling and Control, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, Pa. 18015-4791, (610) 758-4781; Fax: (610) 758-5297; E-Mail: cg00@lehigh.edu.
Diamond Center for Economic Education

The Center for Economic Education was established in 1976. It is part of a nationwide network of more than 270 such centers under the guidance of the EconomicsAmerica-National Council on Economic Education. It is also one of 12 Centers in the statewide network affiliated with the EconomicsAmerica-Pennsylvania Council on Economic Education.

For more than a quarter of a century, the Joint Council has been involved in programs to reduce the level of economic illiteracy in the United States. The purpose of Lehigh's center is to increase the quantity and improve the quality of economic education.

Located in the Rauch Business Center, the center is part of the College of Business and Economics. But it takes on an interdepartmental role as it coordinates programs aimed at heightening understanding of the American business and economic system. The center also serves as a clearing house for educational ideas. It also houses an expanding resource library including books, videos, curriculum material, testing packets, and simulation games for use by faculty and area educators.

Educational opportunities. The center sponsors workshops, seminars and guest lectures designed to meet the educational needs of faculty and students. Activities and projects, such as the Stock Market Game simulation, allow teachers and students the opportunity to experience the workings of the market and the free enterprise system.

For more information, write to Anthony P. O'Brien, 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 material 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 make their colloidal properties as important as the polymer properties for 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 recipe components during 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 problems: emulsion polymerization kinetics, mechanisms, and morphology of core/shell latexes; colloidal, surface, and bulk properties of polymer colloids; dispersion polymerization; miniemulsion polymerization; inverse suspension polymerization; NMR studies of polymer colloids; particle size characterization via capillary chromatography; and associative thickeners.

Significant research support for institute activities is obtained from industrial organizations through their membership in the Emulsion Polymers Liaison Program. Hence some considerable effort is made to relate the research results to industrial needs. Consequently, graduates can find excellent opportunities for employment.

Educational opportunities. Graduate students in the institute undertake dissertation research leading to the master of science 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, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, Pa. 18015.
Energy Research Center

Energy research at Lehigh is a multidisciplinary activity, involving faculty and students from engineering, the physical sciences, life sciences, business and 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 facilities 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/mass spectrometer, atomic absorption spectrometer, electron optical, mechanical testing, structural testing, welding, metal forming, fracture mechanics, ceramics, polymer, hydraulics and water resources, van de Graaff 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, assuring 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 slagging; 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; 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, 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; 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; siting of wind-power applications.

- **Energy economics.** Dynamic analysis of energy supply-demand systems; model of an investor-owned electrical utility; 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 Sciences, 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 complementing their 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 do 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 some of the outstanding people in the energy fields to the 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) to serve as a national focal point for research and technology aiding structures-related industries. Structural research and materials research is being conducted for the basic infrastructure of bridge, building, offshore-platform, and ship structures. Currently, about 100 persons, including graduate and undergraduate students, research associates, faculty and staff members representing the disciplines important to large structural systems are active in research at the Center.

The research program at ATLSS is cross-disciplinary and broad in scope. Research topics include Innovative Structural Systems and Materials, Life Prediction and Condition Assessment, Renewal Engineering, and Life-Cycle Engineering and Information Systems. The studies include a significant seismic research program.

The projects within these research thrusts follow the structural system life-cycle processes of experimentation, design, fabrication and construction, operation, and retrofit. The ATLSS research studies are conducted in close association with advisory committees of 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 new (1989) large-scale multidirectional loading ATLSS Laboratory, in which researchers evaluate large complex connections, assemblages and structures under static and/or cyclic multidirectional loading with complete computer-controlled experimentation. ATLSS also has outstanding computer resources, and a fine mechanical testing, welding, metallography, and non-destructive evaluation complex.

Research Activities:

High-Performance Materials—Research is conducted on innovative structural forms and structural systems to promote competitive use of new materials. High-performance steel is emphasized, but aluminum concrete, fiber-composite, and mixed systems are included. Bridge and advanced double-hull ship applications are emphasized.

Connection Design Methodologies—an integrated effort to advance connection technology in construction and to establish a connection design methodology. Connections for seismic resistance are emphasized. Further, a new system of patented ATLSS connections has been developed to facilitate fabricability and erection automation. Numerous techniques for improving structural assemblies are being studied.

Condition Assessment of Structures—the development of smart monitoring systems; new intelligent sensors as well as new applications for non-traditional sensors for life prediction and condition assessment. The studies have resulted in new sensor systems for corrosion monitoring and fatigue diagnosis, and a hypermedia bridge fatigue investigator system for bridge inspection and assessing fatigue and fracture damage.

Renewal and Retrofit Techniques—to increase and restore structure durability and strength are being studied for bridge, building and offshore-platform structures.

Educational Opportunities. The ATLSS Center facilitates programs of study and research that cross the traditional boundaries of engineering curricula, providing a fundamental, broad approach to the field of structures.

Graduate students participating in the Center's program
usually receive master of science, master of engineering, or doctor of philosophy degrees in the academic discipline of their choice, i.e., civil engineering, material science and engineering, computer science, industrial engineering, mechanical engineering, etc. However, they are expected to pursue course work related to a broader understanding of structures and to conduct research on a cross-disciplinary problem in the Center.

Financial support for graduate students is available through the ATLSS Research Center by means of fellowships and research assistantships related to sponsored research programs.

Undergraduates also participate in the Center's research and educational program. Opportunities for summer internships and for academic-year special projects are available which enable direct involvement in the Center's research effort.

For more information, write to Dr. John W. Fisher, Director, ATLSS, Lehigh University, 117 ATLSS Drive, Bethlehem, PA 18015-4729.

Health Sciences Institute

The Health Sciences Institute, organized in 1972, is concerned with interdisciplinary research and graduate and postdoctoral training in various aspects of the biomedical sciences and engineering.

A large part of the research conducted at the center is supported by private and public agencies and all are related to either basic or applied aspects of problems pertaining to human and animal life.

Research activities. Interests currently represented among faculty members include the following: immunochemistry applied to clinical diagnostics, modification and use of monoclonal antibodies in radiosensitization and NMR imaging, surface adhesion in biological systems, glycoprotein structure and function, cell-cell interactive proteins, tumor image enhancement, medicinal chemistry, neuroendocrinology, motility and behavior of cells, chemistry of biologically potent molecules, manipulation of bacterial genetics, and recombinant DNA biotechnology.

The administrative offices and most of the laboratories are housed in Iacocca Hall of the MTC. The laboratories are well equipped, and the major pieces of equipment include numerous liquid and gas chromatographs, tissue culture laboratory, bacterial transfer room, fermentors, warm room, cold rooms, scintillation and gamma counters, UV-Vis and infrared (including Fourier transform) spectrophotometers, ultracentrifuges and ancillary equipment necessary to conduct the above studies.

Ongoing interactions with Hahnemann University, St. Luke's Hospital and Lehigh Valley Hospital Center exist; clinical aspects of several research projects are being conducted there.

Educational opportunities in the Health Sciences Institute. Graduate students working under the direction of members of various components of the institute may satisfy course requirements towards the M.S. and Ph.D. degrees by selecting from the offerings of the departments of chemistry, physics, molecular biology, psychology, civil engineering, mechanical engineering and mechanics, as well as other departments.

In addition, the interdisciplinary graduate program in physiological chemistry leading to the master of science and the doctor of philosophy degrees is supported by the Health Sciences Institute, although all of these students are enrolled in the department of chemistry. Students may also pursue graduate degrees in biochemistry, organic, clinical chemistry, or molecular biology under supervision of institute faculty members.

In addition to research, the institute sponsors symposia on topics pertinent to its objectives.

For more information, write to Jack A. Alhadeff, Director, CMBB, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, PA 18015.

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 improving 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.

Established with support and guidance from Lee Iacocca '45, the Institute and its partners have developed four competitiveness program areas: Manufacturing Competitiveness, Educational Competitiveness, Technology Transfer and Policy Studies. Within these areas the Institute seeks to enhance the knowledge and leadership capabilities of U.S. corporate management, entrepreneurs and Lehigh students. The program units under the umbrella of the Iacocca Institute include: the Agility Forum, the Northeast Tier Ben Franklin Technology Center (NET/BFTC), and the Manufacturers Resource Center (MRC).

Current outreach activities in educational competitiveness include the partnership with Cities In Schools, Inc., (Alexandria, VA.), and Lehigh's College of Education. Together they develop the National Center for Partnership Development (NCPD) to help stem the dropout crisis in America and improve basic, intermediate and secondary education throughout the United States. Through the NCPD, training sessions are held at Lehigh to replicate the successful Cities In Schools model across the nation.
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. Barnett, chairman and CEO, Bethlehem Steel Corporation; George M.C. Fisher, chairman and CEO, Eastman Kodak Company; Douglas A. Fraser, former president, United Auto Workers, University Professor of labor studies, Wayne State University; William C. Hittinger, '44, former executive vice president, research and engineering, RCA Corporation; Drew Lewis, chairman and CEO, Union Pacific Corporation; Peter Likins, president, Lehigh University; Thomas J. Murrin, former deputy secretary of Commerce, Dean, A.J. Palumbo School of Business, Duquesne University; John Wells Path '52, J. W. Path Associates; David M. Roderick, former chairman and CEO, USX Corporation; Francis H. Spiegel '57, former executive vice president, March & Company, Inc.; Robert L. Woodson, president, National Center for Neighborhood Enterprise; Jerome B. York, senior vice president and CFO, IBM Corporation.

In 1993 the Iacocca Institute launched a special honors program, The Iacocca Scholars. Ten students are chosen each autumn on the basis of their potential for leadership in areas that enhance national competitiveness such as manufacturing, public policy, and other aspects of both the public and private sectors. Students entering their Junior year or Seniors involved in a five year program are invited to submit an application for this two year affiliation which includes special projects with faculty mentors, interaction with distinguished national leaders, summer internships and other individual and group activities.

Representatives from each of Lehigh's four colleges serve on the Institute's Faculty Program Board.

For more information, write to Dr. Roger N. Nagel, Executive Director, Iacocca Institute, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem, PA 18015.

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.

The Institute has established an extensive network of interaction and generated significant research collaboration with a number of major medical centers. An effective liaison program fosters interaction between the University and industry in the biomedical field.

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, sponsored by the department of materials science and engineering, was established in 1970 to teach the principles and applications of metal-forming technology to graduate and undergraduate students, to provide instruction and equipment for graduate research in metal-forming processes, and to assist industry with solutions to problems in metal forming.

Metal-working processes are analyzed mathematically, usually involving the computer. The results of the analyses are checked and refined by comparison with experimental data obtained in the fully instrumented metal-forming laboratories that are part of the institute's facilities.

In addition, an important part of the effort of the institute is the preparation of educational programs using the latest audio-visual techniques in integrating expert systems provided as software for personal-computer users. These programs are used in the classroom and in institute-sponsored seminars on campus and at industrial facilities.

Research activities. Current research areas include: hydrostatic extrusion; pressure-induced ductility; flow through converging conical dies; effect of holes, inclusions and pressure on tensile properties; friction modeling and measurement; cladding and forming of composite materials; forming of polymers; deep drawing, impact extrusion and iron rolling; and powder consolidation. Special emphasis is currently being given to fabrication of high-temperature ceramic, super-conducting wire, and to computer simulation of metal forming processes.

Educational opportunities. Students interested in metal forming should refer to course descriptions for metallurgy and materials engineering and 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, environmentally accelerated 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; 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.

Solid mechanics. Analytical and numerical methods of analysis.

Plates and shells.

Educational Opportunities. Students interested in fracture and solid mechanics should refer to course offerings in the departments of mechanical engineering and mechanics, metallurgy and materials engineering, civil engineering, chemistry and biology.

For more information, write to George C.M. Sih, Director, Institute of Fracture and Solid Mechanics, Packard Laboratory, Lehigh University, 19 Memorial Drive West, Bethlehem, Pa. 18015.

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 Physical Sciences. 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 the researchers at Lehigh and the 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 program includes 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 Physical Sciences. 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 adviser, 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, Iacocca 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 cost, copying and other expenses to permit scholars to visit necessary libraries and depositories, to help support deserving students in their dissertation year, and to encourage interdisciplinary research activities at Lehigh. 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 the campus distinguished scholars in eighteenth-century studies 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 Press that also publishes original manuscripts on the eighteenth century.

For more information, write to either of the co-directors, William G. Shade, department of History, Maginnes Hall, 9 W. Packer Ave., or Jan Fergus, 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, established in 1984, develops, administers, and coordinates programs in Jewish studies among 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). Housed at Lehigh, 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. A visiting scholar from Israel is in residence at the center annually and teaches courses at Lehigh and other LVAIC schools.

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, Tel Aviv University, and the Tel Miqne-Ekron Archaeological Project. For further information on Israel study programs, contact Shirley Ratushny, 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, 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 Perspectives on Business and Economics. The center has established the Canadian Studies Institute which encourages scholarships 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 persons, 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; guide the search for new materials by encouraging fundamental research and new approaches to materials problems; and 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 five laboratories: the electron optical, ceramics, thin films and coatings, engineering polymers and mechanical behavior laboratories, located in Whitaker Laboratory. Current interdisciplinary research activities include:

**Electron optics.** Characterization of fracture surfaces in polymers, ceramics, and steels by scanning electron microscopy; x-ray microanalysis of extraterrestrial materials, ferrous alloys, geological materials and ceramics using the electron problem microanalyzer; transmission and scanning transmission electron microscopy studies of grain boundaries in oxides; and metals, domain structures in ferroelectrics; low-temperature phase transformations in iron alloys; interfacial reactions in composites, and chemistry of nanometer-size catalyst particles.

**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; sintering studies and additive effects; microstructural characterization of ceramic materials; microstructure design of structural ceramics for optimum mechanical behavior.

Defect structure and impurity interactions in insulating, semiconducting, and superconducting oxides; microstructural characterization of ceramic materials; microstructure design of structural ceramics for optimum mechanical behavior.

**Mechanical behavior.** Effect of polymer chemistry and molecular structure on fatigue crack propagation (FCP); test frequency sensitivity and fatigue fracture mechanisms 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.

**Polymers.** Structure, morphology and mechanical behavior of interpenetrating polymer networks; thermosetting resins; vinyl polymers; polymers based on renewable resources; permeability and mechanical behavior of membranes, coatings, and filled polymers.

**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 electro deposition; 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 expected to pursue coursework related to a broader understanding of materials and to conduct research on an interdisciplinary materials problem in one of the center’s five laboratories.

Financial support for graduate students is available through the Materials Research Center by means of research assistantships related to sponsored research programs.

For more information, write to Martin P. Harmer, Director, Materials Research Center, Lehigh University, 5 E. Packer Avenue, Bethlehem, Pa. 18015-3195.

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**The Murray H. Goodman Center for Real Estate Studies**

The Murray H. Goodman Center for Real Estate Studies 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 has been 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 monies 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 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 contracts. Opportunities for marketing to prime contractors are also promoted. Contract administration and general business assistance 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 one hundred, fifty students per year gain practical experience by providing counseling to sixty businesses.

ACE. The enrichment of entrepreneurship programs at Lehigh is accomplished in part by the Association of Collegiate Entrepreneurs. Through ACE, students meet entrepreneurs and promote 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 ohn W. Bonge, Director, Musser Center for Entrepreneurship, Rauch Business Center, 621 Taylor Street, Bethlehem, PA 18015.

The Philip Rauch Center for Business Communications

The Philip Rauch Center for Business Communications was established in 1981 in Lehigh's College of Business and Economics in response to a growing need for more effective communication in business. The Center was established with a gift from Philip Rauch '33, who is a retired chairman of the board of Parker Hannifin Corporation.

The center's mission is to help students develop the skills needed to write effective professional memos, letters and reports, and make successful oral presentations.
In support of the Undergraduate Writing Requirement Program in the College of Business and Economics, the Center's staff collaborates with CBE faculty from all academic areas to reinforce and improve student writing skills. The Center also operates a Business Writing Clinic which invites students to drop by any time during business hours for counseling on writing projects. The Center's HOMEPAGE on the Internet offers a "Virtual Clinic", offering advice on writing projects and the design and delivery of oral presentations. Students taking business communication courses receive training in the use of presentation software, LCD panels and laptop computer technology in their class presentations.

The Center sponsors workshops for faculty and students on the use of communication technology.

Research Activities. The Center's HOMEPAGE offers faculty and student access to INTERNET research tools and resources dealing with the theory and practice of written and oral communications. Undergraduate and graduate students can explore the results of student research projects. Students will also be able to review student Powerpoint presentations.

Supported by a grant from AT&T, the Center has created an Internet link to relevant resources dealing with doing business with and in Asia. A multimedia computer located in the Center serves as a permanent site for displaying this information and members of the Lehigh Valley community are welcome to use this resource.

The Center is in the process of developing multimedia business cases which will support our business curriculum and integrate writing across the curriculum.

Beginning in the Fall of 1996, the Center will offer grants of $5,000 to researchers who study written and oral communications. The results of this research will become part of our Center's Internet Library of research.

For more information, write Peter M. Saunders, 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 fifty 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 aims to develop 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. Research scientists from two research institutes at Lehigh University also participate in the Center's research. The current research effort is divided into three theme areas:

- 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, TiO$_2$, and silica.
- 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.
- Mechanical behavior of polymer systems. PIC researchers examine the mechanical behavior of polymer systems that innately contain interphase regions or are purposely modified to incorporate interphases. Selected projects include investigations of film formation, properties associated with films derived from thermoplastic and cross-linkable latexes, and "toughening" mechanisms and fatigue resistance in plastics that are modified with rubbery and/or glassy inclusions.


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
There are a few opportunities for research by undergraduates who have achieved senior standing in a science or engineering major.

For more information, write to Mohamed S. El-Aasser, Director, Iacocca Hall, Lehigh University, 111 Research Drive, Bethlehem PA 18015; or call (610) 758-3590.

Sherman Fairchild Center for Solid-State Studies

Although work in other aspects of solid-state is carried out in many locations on the Lehigh campus, the Sherman Fairchild Laboratory provides the focal point for studies of electronic materials and devices. Opened in the fall of 1976, the building provides offices and laboratories for an interdisciplinary staff consisting of faculty from the departments of physics, materials science and engineering, and electrical engineering and computer science.

Research activities. A central theme involving the nature and role of defects in insulators and semiconductors runs through the research program. Areas of study include quantum theoretical predictions of electronic properties, fabrication of materials and devices for the study of material processing; the elucidation of fundamental electronic, optical and transport behavior; design, fabrication and characterization of novel electronic devices. The research has a current emphasis on silicon, silicon oxides and silicon-related technology, but also includes work on compound semiconductors; complex insulators such as niobates and titanates, and high-temperature ceramic superconductors.

Central to the functioning of the research program is the Microelectronics Research Laboratory, which provides processing facilities for the fabrication of CMOS, CCD, MNOS, bipolar devices and integrated circuits. Available technology includes low-pressure chemical vapor deposition (LPCVD), RF metallization, plasma chemistry, photolithography, ion implantation, high pressure oxidation, and standard oxidation and diffusion. A new Thin Film Device Laboratory has been established to work on electronic devices and materials for large flat panel displays. Design of circuits and devices is aided by an Applicon Color Graphics VLSI system, and a HP-IB system permits automatic data acquisition and analysis of device characteristics.

A 3 MeV Van de Graaff accelerator provides a radiation facility that can be used to produce electrons for the generation of point defects. Individual laboratories provide instrumentation for studies of transport properties at millikelvin temperatures, optical excitation and luminescence, electron tunneling, electronic conduction and trapping, electron paramagnetic resonance (EPR) and optical detection of magnetic resonance (ODMR), deep level transient spectroscopy (DLTS), and fourier transform infrared spectroscopy (FTIR).

Current research programs include (1) fundamental radiation damage processes in silicon, an experimental and theoretical program aimed at unraveling the fundamental properties of simple lattice point defects in silicon; (2) a study of the electronic and vibronic structure of intrinsic lattice defects in compound semiconductors, an experimental study of the fundamental properties of simple crystalline point defects in the compound (II-VI, III-V) covalent semiconductors; (3) point defects in insulating solids, experimental studies and theoretical calculations on electron/hole transport, trapping and defective properties; (4) tunneling in MIS memories, an exploration of the dominant physical process in nonvolatile semiconductor memories, namely tunneling of carriers into and through an insulator; (5) VLSI microelectronics, a study of the characterization of small geometry solid-state devices for VLSI, with emphasis on CMOS transistors; (6) semiconductor charge transport devices, a study of novel device and sensor structures that evolve charge transport and storage. The characterization and modeling of MNOS nonvolatile memory structures; (7) microstructure of electronic materials, microstructural studies of electronic devices, passive components and processing materials to elucidate fundamental mechanisms that govern device performance, to improve device performance and explore novel methods of fabrication; (8) study of thin film materials and device structures for large flat panel displays.

Educational opportunities. Graduate students in the field of solid-state science and engineering usually enroll for the master of science or doctor of philosophy degree in the traditional discipline of their choice, such as physics, metallurgy and materials 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 sources. 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 undertake 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.

For more information, write to Michael Stavola, Director, Sherman Fairchild Center for Solid-State Studies, Sherman Fairchild Laboratory, Lehigh University, 16A Memorial Drive East, Bethlehem, Pa. 18015.
Small Business Development Center
(see Musser Center for Entrepreneurship)

The SMART Center

The SMART (Science Model Area Resource Team) Center was established in 1992 to contribute to national efforts to achieve science and mathematics literacy for all Americans. Achievement of this goal requires innovative reforms in the areas of science, mathematics and technology, education including an increasing emphasis on informal science education. In April 1995, the Center opened to the public as the SMART Discovery Center, a hands-on exhibit center for informal science, mathematics and technology education in a relaxed, nontraditional setting. The mission of the SMART Discovery Center is to promote both formal and informal learning about science, mathematics and technology through participatory exhibits, resources, training, degree programs, research and development for students, families, and the community with attention to the historically underserved and underrepresented. Research and assessment continue to be a significant part of SMART Discovery Center activities.

The center serves as an umbrella for a wide variety of training, research and development, and assessment programs for both teachers and students of science, engineering and mathematics. Several disciplines are involved in the activities of the center including: leadership, instruction and technology; architecture; environmental science; chemical engineering; school psychology, counseling psychology and special education.

The center serves as a resource in the promotion of science and mathematics education activities throughout the region. Individuals, families, school and community groups are welcome to come to the hands-on exhibits open to the public. Through dissemination of a newsletter (published three times per year), elementary and secondary teachers in the region are encouraged to pursue enrichment opportunities offered by the center.

Training/Educational opportunities. The center sponsors workshops and enrichment programs to meet the educational needs of elementary and secondary teachers and students. In addition to annually presenting the JASON Project to over 10,000 Lehigh Valley residents and students, thousands more visit the Center's hands-on science exhibits. The Center also offers professional development workshops for educators, as well as extracurricular opportunities in science and architecture for students (Saturday and summer camps). Students enrolled in the College of Education may assist in the development of Center workshops and programs.

Research and Development activities. The center is concentrating its efforts in the area of educational opportunities in science and technology for people with disabilities. The Archi-Kids program (a multidisciplinary focus on architecture) has been expanded to emphasize participation by minority, female and economically disadvantaged students at the middle grade level.

Assessment activities. Evaluating the impact of reform efforts is a major focus of the center's activities. The Center continues to assess the influence of the JASON Project on student attitudes toward science and related careers. Future plans include assessment of the exhibit effectiveness and impact on visitors' knowledge.

For more information, write to Dr. Judith A. Bazler, Director, SMART Discovery Center, 715 E. Third Street, Bethlehem, Pa. 18015.

Technology Studies Resource Center

The Technology Studies Resource Center, based in the College of Arts and Science, 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 non-academic 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 for activities are the development and dissemination of resource materials, professional development programming, educational programming, 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; sponsoring a regional colloquium in technology studies and publishing its best presentations in a working papers format; editing the continuing book series RESEARCH IN 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. Cutchliffe, 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. 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 research projects with industries and governmental agencies.

The center is well equipped with specialty instrumentation needed for advance research in its field. Sinclair Laboratory houses equipment for experimental studies employing flash desorption, Moessbauer spectroscopy, Auger spectroscopy, laser Raman spectroscopy, X-ray photoelectron spectroscopy (XPS), high resolution electron energy loss spectroscopy, low energy electron diffraction, ultraviolet photoelectron spectroscopy, nanosecond fluorescence spectroscopy, ellipsometry, computerized spectrophotometry, positron annihilation spectroscopy, electrochemical impedance spectroscopy, 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 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; formation of monolayer oxides on oxides of different metals; the interaction between these oxides and relationship with catalytic activity; surface magnetic properties; wetting of multiphase systems; characterization of surfaces; microelectrophoresis and continuous electrophoresis; Moessbauer spectroscopy of surfaces; 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 lithographic, flexographic and gravure printing; rheology in non-Newtonian fluids; and adhesion and flow of fluids in porous substrates.

Educational opportunities. The center is a facility in which graduate students undertake thesis and dissertation research leading to the M.S. or 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, adhesion, 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 Drive, Bethlehem, Pa. 18015.
Organizational Headquarters for Applied Technology

Ben Franklin Technology Center

The Northeast Tier Ben Franklin Technology Center (NET/BFTC), based in the Ben Franklin Building on the Murray H. Goodman Campus, was established in 1983 as part of the commonwealth's Ben Franklin Partnership. The Center supports and promotes technological innovation in the commonwealth.

The Partnership aims to combine the resources and expertise found throughout the state's educational system with business's technology-advancement efforts to create products and improve manufacturing processes and productivity. Through these efforts, the Ben Franklin program serves to make the state's economy more innovative and competitive, thus creating and retaining high quality job opportunities in Pennsylvania. Past efforts at the Center have been documented as producing over 9000 jobs created or retained, and an independent study showed that taxes resulting from those jobs produce more to the state on a yearly basis than the funds appointed for the Center. The technology center at Lehigh is one of four centers in the state working with business, education and government toward these goals; the other centers are based at the University City Science Center, Philadelphia; Pennsylvania State University, University Park; and Carnegie-Mellon University/University of Pittsburgh.

The goals of the NET/BFTC include helping new technology-oriented businesses to form and grow, helping existing manufacturers to improve productivity through new technologies and practices, and helping to insure a qualified work force. Technical and business assistance services are provided on a year-round basis. The center also operates a business incubator center right on the Lehigh campus, and it seeds the development of creative new education and training programs that meet the needs of industry.

For the 1994-95 funding year, the NET/BFTC was awarded over $6 million from the state Department of Commerce with approximately $13 million in matching funds committed from private-sector businesses, educational institutions and other sources. Each year the NET/BFTC has about 40 projects with Lehigh, involving over 100 faculty members, research scientists, project engineers, students, technicians, and administrative staff.

For more information, contact Mark S. Lang, Executive Director, Ben Franklin Center, Lehigh University, 125 Goodman Drive, Bethlehem, Pa. 18015-3715; (610) 758-5200.

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 consulting nongovernmental organization to 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 seven groups that carry out the major activities of the Council are:

- Planning and Environmental Criteria for Tall Buildings (PC).
- Development and Management (DM).
- Tall Building Systems and Concepts (SC)
- Building Service Systems (BSS)
- Tall Building Criteria and Loading (CL)
- Structural Design of Tall Steel Buildings (SB) and
- Structural Design of 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 seventy 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, 13 E. Packer Avenue, Bethlehem, Pa. 18015; Phone: (610) 758-3515, Fax: (610) 758-4522.

Manufacturers Resource Center

The Manufacturers Resource Center (MRC) is one of eight Industrial Resource Centers Networked across Pennsylvania with the sole mission of helping small and medium-size manufacturers to remain competitive in the current global marketplace. MRC performs the same function as a member of the federally-funded Manufacturing Extension Partnership.

The MRC offers manufacturers valuable assistance by helping companies to use off-the-shelf technology and proven techniques to compete in today's economy. That includes all aspects of business from quality to information systems and production constraints. One-on-one projects are the focal activity of the Center. Each staff manufacturing engineer provides customized analysis for each client, personally defining their particular constraints, and working with them through projects to arrive at solutions. Beyond the information and expertise, the staff engineers act as project managers to the client as they work with a network of private and academic consultants.

Typical services fall into the following categories: manufacturing strategies and plant operations; technology improvement; production planning and inventory control; factory automation; quality management; information systems; equipment justification; plant layout; fixed asset and cost management; business planning and systems layout; work force development; market expansion; labor/management relations; and quality, productivity, marketing and information systems reviews.

Resources available through MRC are experienced staff and industry professionals, private and academic consultants, customized training programs, library of manufacturing materials and access to databases. Additionally, technical demonstration sites have been established where manufacturers are able to observe, learn, and try new technologies. These sites include CIMLab, Lehigh University, Northampton Community College, and the IRC's Shop With a Future.

The MRC serves six counties in Northeast Pennsylvania and is a member corporation of Lehigh University. A sister organization to the Ben Franklin Technology Center, the Center is funded by the Pennsylvania Department of Commerce, the National Institute of Standards and Technology's Manufacturing Extension Partnership and has the support of private industry.

Additional services available through MRC include industry initiatives, regional seminars/training, quality initiatives, ISO 9000 certification seminars and topic specific users groups. For further information or assistance, please contact Edith Ritter, Executive Director, at (610) 758-5599.

Structural Stability Research Council

The Structural Stability Research Council (formerly Column Research Council) was founded in 1944 by the Engineering Foundation to review and resolve the conflicting opinions and practices that existed at that time with respect to solutions to stability problems, and to facilitate and promote economical and safe design. The Council has been headquartered at Fritz Engineering Laboratory since 1966.

At the core of the Council's activities are 17 task groups and 8 task reporters. At its Annual Technical Session, a forum is provided whereby the latest research results pertaining to these groups are presented. This represents a primary source of the highlights of the latest solutions to structural problems before they are eventually published in technical journals.

The Council offers guidance to specification writers and practicing engineers by developing both simplified and refined calculation procedures for the solution of stability problems, and assessing the limitations of these procedures. The Council's major publication is the Guide to Stability Design Criteria for Metal Structures. Now in its fourth edition, this book is the most comprehensive treatment available anywhere in the world on stability problems associated with metal structures.

The international membership of the Council is made up of representatives from governmental and private organizations concerned with specifications and design procedures for metal structures, representatives of consulting firms engaged in engineering practice, members-at-large selected from universities and design offices, and corresponding members from various countries who are in touch with stability research in their region.

A number of Fritz Engineering Laboratory research projects have received the guidance of the Council's advisory committees. Many former Lehigh University graduate students and research workers are now active members of the Council. Many of them are expected to participate in the SSRC's 50th Anniversary celebration to be held on Lehigh campus in June 1994.

For more information, contact Dr. James M. Ricles,
Director, SSRC, Fritz Engineering Laboratory, 13 E. Packer Avenue, Lehigh University, Bethlehem, PA 18015.
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 Science 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. Mathematical

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

Professors. James A. Largay, III, Ph.D. (Cornell), C.P.A., Arthur Andersen & Co. Alumni Professor of Accounting; John W. Paul, Ph.D. (Lehigh), C.P.A., Kenneth F. Sinclair, Ph.D. (Massachusetts), Coopers & Lybrand Professor of Accounting.

Associate professors. D. Raymond Bainbridge, Ph.D. (Lehigh), C.P.A.; Karen M. Collins, Ph.D. (VPI), C.P.A.; Michael L. Davis, Ph.D. (Massachusetts), C.P.A.; Parveen P. Gupta, Ph.D. (Penn State); James A. Hall, Ph.D. (Oklahoma State), Deloitte & Touche Information Systems Fellow; Manash R. Ray, Ph.D. (Penn State); James E. Rebele, Ph.D. (Indiana), Coopers & Lybrand Professor.

Assistant professors. Marilyn M. Greenstein, Ph.D. (Temple); Donald R. Trippe, Ph.D. (South Carolina).


The Accounting program offered by the department of business provides a wide variety of courses in accounting which: support the College of Business and Economics core requirements; provide an undergraduate major in accounting; are elective courses for other College of Business and Economics undergraduate majors; and form a key component of the Master of Business Administration program. The upper-level undergraduate courses have a professional accounting orientation which continues to sustain a large enrollment in the accounting major. Within the major, there is the opportunity to explore the various career opportunities within the broad field of accounting: financial, managerial, taxation, auditing, and information systems.

Objectives of the Accounting Program
The primary goals of Lehigh's undergraduate program leading to the Bachelor of Science degree in Business and Economics with a major in accounting are to:

Cultivate an inquiring mind and kindle the student's interest in lifelong learning
Subject the student to a rigorous academic program in the liberal arts in addition to business and economics
Provide the student with a theoretical framework as well as problem-solving skills in each of the following areas in accounting: financial, managerial, information systems, auditing, and taxation
Encourage the development of interpersonal skills including oral and written communication skills
Promote self-development through participation in extracurricular and social activities.

To the extent the above objectives are achieved, the graduate is prepared for the following: an entry level position in industry, not-for-profit organizations, public accounting; self-employment; and graduate studies. This academic program prepares interested students for relevant professional accounting examinations.

The Accounting Major
The undergraduate program in accounting is accredited (Type A) by the American Assembly of Collegiate Schools of Business. This achievement places the program within a small group of schools nationally 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 program is offered in the College of Business and Economics. Required: 18 credit hours beyond core requirements.
Undergraduate Courses in Accounting

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.

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.

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.

Courses numbered 200 and above in the College of Business and Economics are open to sophomores only on petition.

211. Management Information Systems
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. Prerequisites: Acct 152, Mgt 1 and Mgt 270. Students will not receive credit for both Acct 211 and Acct 311.

Advanced Undergraduates and Graduate Students

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.

309. Advanced Federal Income Taxation (3)
An advanced study of the taxation of business organizations, estates, trust, and wealth transfer taxes. Planning and research are the basic components of the course. Problem-solving and written research are emphasized. Prerequisite: Acct 307.

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 reports and documents generated by information systems, as well as procedures and controls employed in a variety of business applications. Students apply these concepts, techniques and procedures to the planning, analysis and design of manual and computer based information systems. Prerequisites: Acct 152, Mgt 1, and Mgt 270. Students will not receive credit for both Acct 211 and Acct 311.

315. Financial Accounting I (3)
Intensive study of the basic concepts and principles of financial accounting, emphasizing the problems of fair presentation of an entity’s financial position and operating results. Consideration of the conceptual framework of accounting, review of the accounting process, and measurement and valuation of current assets, current liabilities, plant assets, intangibles, investments, and long-term debt. Problem-solving skills and critical analysis are stressed. Prerequisite: Acct 152.

316. Financial Accounting II (3)
The sequel to Accounting 315, this course continues with intensive study of such topics as stockholders’ equity, valuation and disclosure of leases and pensions, income tax allocation, changing prices, revenue issues, earnings per share, and complexities related to the statement of changes in financial position. Analysis and interpretation of financial statements and problem-solving skills are integral parts of the course. Prerequisite: Acct 315.

317. Advanced Financial Accounting (3)
A study of specialized topics in financial accounting, including partnership accounting, business combinations and consolidated financial statements, segment and interim reporting, foreign currency transactions and translation, and accounting and reporting for governmental and other nonprofit organizations. Involves considerable problem-solving and critical evaluation of controversial theoretical issues. Prerequisite: Acct 315 or 316.

320. Fundamentals of Auditing (3)
An introduction to auditing theory, objectives, and practices related largely to the responsibilities of independent professional accountants. The auditing environment, generally accepted auditing standards, internal control theory, and reporting alternatives are considered. Exposure to operational auditing is provided. Prerequisites: Acct 311 and 315.

324. Cost Accounting (3)
An in-depth study of cost concepts appropriate for product costing in a manufacturing operation, planning and controlling routine operations, and nonroutine decision-making. Topics include job order and process costing, joint and by-products, cost allocation, budgeting, standard costing, direct costing, cost-volume-profit analysis, and relevant costs for decisions. Prerequisite: Acct 152.

371. Directed Readings (1-3)
Readings and research in various fields of accounting; designed for superior students who have a special interest in some topic or topics not covered by the regularly rostered courses. Written term paper(s) required. Prerequisite: preparation acceptable to the department chairperson.

372. Special Topics (1-3)
Special problems and issues in accounting for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of the instructor and students. Prerequisite: preparation acceptable to the department chairperson.

370. Internship (1-6)
Designed to give advanced students of accounting, who have maintained a satisfactory standard of scholarship and who show promise in the field of accounting, an opportunity to acquire field experience and training with selected industrial or public accounting firms or governmental agencies as a complement to the academic learning process. Outside readings are assigned. Written reports are submitted by students and a performance evaluation is made by the employer. The amount of credit is influenced by the length of the training period. Prerequisite: junior standing and approval of the faculty committee on internship.

Graduate Courses in Accounting
Undergraduates may wish to plan a program that includes the M.B.A. degree as part of the professional accounting preparation. For information about C.P.A. requirements in different states, the C.M.A. certificate, or for the selection of accounting electives, consult the department chairperson.

403. Financial Flows and Accounting Measurements (3)
Corporate financial reporting: identification, accumulation and communication of financial information to management and other users. Generally accepted accounting principles, uses and limitations of accounting information, asset valuation, income determination, funds flows, and analysis and interpretation of financial statements.

413. Managerial Accounting and Decision-Making (3)
Cost accounting techniques for management planning and control. Responsibility accounting, budgeting, cost behavior, cost estimating, and allocation, product costing, relevant costs, cost variance analysis, information requirements. Prerequisite: Acct 403 or equivalent.

421. Information Systems for Managers (3)
Information processing, computer, and data structure concepts in producing information. Communications between user management and data processing management in the systems development process. Control of systems development activities, data based systems, and distributive processing systems. Projects and case studies. Prerequisites: Mgt 413 (or concurrently) and Acct 403.

431. 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.

433. (IE 408) Management Information Systems (3)
Integrated and total systems concepts for organizational data bases and information systems as applied to planning, development and implementation of computer-based management information systems. Emphasis placed on the interaction of information systems with management planning and control. Prerequisite: an advanced course in information systems and a knowledge of programming.

435. Advanced Management Accounting (3)
Issues in management accounting including activity based costing, strategic cost management, theory of constraints, advanced manufacturing technologies, cost of quality, and life cycle costing. Readings and cases. Prerequisite: Acct 413 or a course in cost accounting.

439. 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: Acct 413.

471. Directed Readings (1-3)
An extended study of an approved topic in the fields of accounting. May be repeated.

472. Special Topics (1-3)
Special problems and issues in accounting and law for which no regularly scheduled coursework exists. When offered as group study, coverage varies according to interests of the instructor and students. Prerequisite:
preparation in accounting acceptable to the department chairman. May be repeated.

**African American Studies**

**Professors.** William R. Scott, Ph.D. (Princeton), Professor of History, program director; Elizabeth N. Fifer, Ph.D. (Michigan), professor of English; William G. Shade, Ph.D. (Wayne State), professor of history; Jean R. Soderlund, Ph.D. (Temple), professor of history.

**Assistant professors.** Bertrisford W. Boothe, M.F.A (Maryland Institute College of Art), assistant professor of art and architecture; Melvin Thomas, Ph.D. (Virginia Polytechnic), assistant professor of sociology and anthropology.

**Adjunct professors.** Tori Bronaugh, (City University of New York); Karen R. Keim, Ph.D. (Indiana); Curtis Keim, Ph.D. (Indiana).

The purpose of the African American Studies Program is to engender in Lehigh students an intellectual appreciation of the life and culture of people of African descent in the Americas, especially 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, African American Studies expands all Lehigh students' critical understanding of their own heritage in interaction with other cultures.

The minor in African American 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 African Americans. The African American Studies curriculum encompasses two interrelated lines of inquiry: (1) the diverse influences in Africa and the 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 Minor**

The minor in African American Studies consists of a minimum of 15 credit hours taken in the courses (core and collateral) listed below. At least nine (9) credit hours must be selected from the Core Course grouping (excluding independent and special topics), no more than six hours of which may be offered by the same department. In addition to the listed courses, students are encouraged to pursue independent study opportunities with faculty in the African American Studies Program.

**Core Courses:**

Core courses concentrate on subject material directly relevant to the African American experience. They are devoted explicitly to the study of the African American experience or heritage.

AAS 3. Introduction to African American Studies (3) An interdisciplinary study of key aspects of the past, the culture and political experience of African Americans. The history of Africans in America, cultural continuities among African peoples worldwide, and social forces that have shaped modern African American life. Scott. (SS)

AAS 5. (Hist 5) African Civilization (3) 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; neocolonialism. Keim. (SS)

AAS 38. (Engl 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; films on contemporary Africa. Keim. (HU)

AAS 103. (SSP 103) Race Relations (3) Racism, discrimination and prejudice, racial and ethnic conflict, and racial oppression in American society, the Civil Rights Movement. Problems faced by Blacks, Hispanics, Native Americans, and Asians in contemporary United States. Thomas. (SS)

AAS 129. (Hist 129) Black Political Thought in America (3) Black leadership, organizations, and philosophy in America from Reconstruction to the Civil Rights Era; ideas and programs of Booker T. Washington, W. E. B. Du Bois, Marcus Garvey, Martin Luther King, Jr. Scott. (SS)

AAS 130. (Hist 130) African American History to 1865 (3) Blacks in North America and the West Indies from first importation of Africans until end of the Civil War; West African origins, slave trade; variant slave systems; black culture; free blacks, manumission, proslavery ideology and blacks during the Civil War. Soderlun. (SS)

AAS 131. (Hist 131) African American History Since 1865 (3) Failure of Reconstruction; sharecropping; Jim Crowism; segregation; lynching; urban migration; Harlem Renaissance; New Deal; Civil Rights Movement; Black power. Scott. (SS)

AAS 150. (Art 150) Africans in the New World (3) Spring African-American art, architecture, and craft from precolonial Africa to the present. Early primitivism, neoclassicism, the Harlem renaissance, modernism, and contemporary directions. Guest lecturers, open dialogue, gallery visits, and media presentations. Writing Intensive. Boothe. (SS)
American Studies is an interdisciplinary major emphasizing the idea that the institutions and values of a society comprise a whole, not merely the sum of its parts. By concentrating on the unique expressions of individuals contained in both the arts and popular culture and by studying the historical movements and contemporary institutions within which these expressions develop, American Studies reveals relationships that may not be clearly seen within the framework of a single discipline.

The broad interdisciplinary nature of American Studies equips the student with a well-rounded general education and a wide range of career opportunities. The student may choose to emphasize American history or literature to provide an excellent preparation for graduate school in these areas as well as in American Studies. In addition the major can be combined with other majors, such as journalism, or minors, to furnish a sound underpinning for careers in those areas.

With suitable collateral courses, the major also can prepare students for advanced work in museum administration, library science, social work and for teaching in both secondary schools and community colleges.

The major consists of fifteen credit hours of preliminary courses dealing with American literature, history, and popular culture. All students are also required to take two American Studies courses, one at the intermediate level introducing the general approach of the major and a senior seminar on contemporary American civilization. In connection with the director of American Studies, who serves as the adviser for the major, each student chooses a program of fifteen semester hours of upper-level courses drawn from four different groups. The major requirements total 36 credit hours.

required preliminary courses (15 credit hours)
Hist 9 Survey of American History I (3)
Hist 10 Survey of American History II (3)
Engl 123 American Literature I (3)
Engl 124 American Literature II (3)

Choose three hours in the area of American Popular Culture from the following:
Engl 163 Narrative Film (3)
Engl 189 Popular Literature (1-3)
Hist 7 Machine in America (3)
Rel 180 Religion and the American Experience (3)
SSP 152 Alcohol, Science and Society

required American Studies courses (6)
Intermediate level: Arts 111. The American Character (3)
Upper-level seminar: Arts 311. Themes in Contemporary American Civilization (3)

required upper-level courses (15)
Choose at least six hours each from two groups.

Literature
Engl 376 Early American Literature (3)
Engl 377 American Romanticism (3)
Engl 378 American Realism (3)
Descriptions of Courses

Engl 379  Twentieth-Century American Literature (3)  Murray Schechter, Ph.D. (N.Y.U.); Gilbert A. Stengle, Ph.D. (Wisconsin); Joseph E. Yukich, Ph.D. (M.I.T.).
Engl 380  Contemporary American Literature (3)  
Engl 382  Themes in American Literature (3)  

History
Hist 120  Revolutionary America (3)  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.
Hist 319  Colonial America (3)  For a description of the graduate programs in Applied Mathematics, see the discussion under Interdisciplinary Graduate Programs on page 66 in Section IV.
Hist 325  History of Sexuality and the Family in U.S. (3)  
Hist 326  Social Class in America (3)  
Hist 327  American Intellectual History (3)  
Hist 328  American Intellectual History (3)  

Government and Society
Govt 317  The American Presidency (3)  
Govt 330  Politics of the 1960s (3)  
Govt 351  Constitutional Law (3)  
US 321  White Protestants Americans (3)  
SSP 141  Social Deviancy and Social Control (3)  
SSP 165  Contemporary Social Problems (3)  
SSP 364  Sociology of the Family (3)  

Choose three hours from the following
Minorities in America
US 328  The American Jewish Community (3)  
Engl 311  Literature of Women (3)  
Engl 316  Native American Literature (3)  
Hist 130  African American History to 1865 (3)  
Hist 131  African American History since 1865 (3)  
Hist 124  Women in America (3)  
Anth 182  North American Indians (3)  
SSP 103  Race Relations (3)  

The courses listed here 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 of the committee in the student’s junior year. The student must attain an average of 3.2 in major courses in addition to the university honors requirements.

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); Gregory T. McAllister, Ph.D. (Berkeley); lead; George E. McCluskey, Ph.D. (Pennsylvania); Eric P. Salathe, Ph.D. (Brown);

Art and Architecture

Professors. Ivan Zaknic, M. Arch. and Urban Planning (Princeton), Chairman; Tom F. Peters, M. Arch (ETH Zurich (dip 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.


Assistant professors. Bertrand W. Booth, M.F.A. (Maryland Institute College of Art); Bruce Thomas, Ph.D. (Univ. of Calif., Berkeley); Anthony Viscardi, M.Arch (Georgia Institute of Technology).

Lecturers. Christine Ussler-Trumbull, M.Arch (Columbia University).


Adjunct lecturers. Steven Anderson; Myron Barnstone; Anthony Corallo; Ben Marcune; Douglas Mason.

The department of art and architecture offers two major programs:

The architecture major is a multidisciplinary major based in the department that draws on the resources of all Lehigh’s colleges. Although architectural design is the primary concern of this major (beginning students should take Arch 1 and Art 7) courses in architectural history, social sciences and engineering are recommended.

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 or for planning, preservation, or history of architecture.

In recent years students have gone on to graduate study in architecture at Yale, Harvard, Penn, Columbia, University of Pennsylvania, Maryland and Washington University, among other schools, or to entry-level employment in the profession.

Double majors with 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 engineering students considering graduate study in architecture or entry-level positions in an
architectural-engineering firm an architecture minor is generally appropriate.

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 a student can expect to take more than the required number of credits for the major.

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.

Through the facilities of the Lehigh University art galleries, it is 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 has brought 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, Jody Pinto have come to Lehigh. Cooperation with Moravian College allows students to register for art courses not offered at Lehigh, such as ceramics.

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/architecture history, graphic communication, and museum studies. Course requirements are specified, and a list of courses acceptable for the minors is available in the department.

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-six credit hours are required.

required preliminary courses (25 credit hours)
Art 1 or Arch 1 Art History 1 or Architectural History I (3)
Art 2 Art History II (3)
Art 7 Basic Design (3)
Art 8 Foundation in Drawing and Design (4)
Art 13 Sculpture I (3)
Art 15 The Figure (3)
Art 111 Drawing II (3)
Art 220 20th-Century Art (3)

plus one of the following:
Art 82 Art and Archaeology of Greece (3)
Art 121/WS 121 Women in Art (3)
Art 150/AAS 150 Africans in the New World (3)
Art 175 Introduction to Museum Work (3)
Art 206/Arch 206 Medieval Art and Architecture (3)
Art 207/Arch 207 Renaissance Art and Architecture (3)
Arch 210 20th-Century Architecture (3)

six required 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 Architecture 1 and 2, Art 7 and Art 8, plus one other studio. At least six courses in art history should be selected in consultation with instructor. Priester

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 instructor. Viera
Architecture Major

Fifty credit hours are required.

Design Sequence (22 credit hours)
Arch 043 Architectural Design I (4)
Arch 143 Architectural Design II (6)
Arch 243 Architectural Design III (6)
Arch 343 Architectural Design IV (6)

Art Studio (10 credit hours)
Art 7 Basic Design (3)
Art 8 Foundation in Drawing and Design (4) plus one other studio (various choices) (3)

Architectural History (9 credit hours)
Art 1 or Arch 1 Art History I or Architectural History I (3)
Arch 2 Architectural History II (3)
Arch 210 20th Century Architecture (3)

Architecture and its intellectual context (9 credit hours)
(including Architecture and Technology courses)
Arch 107 History of American Architecture (3)
Arch 204 Ancient City and Society (3)
Arch 206/Art 206 Medieval Art and Architecture (3)
Arch 207/Art 207 Renaissance Art and Architecture (3)
Arch 209 Architecture and Ideas since 1750 (3)
Arch 213 The City (3)
Arch 342 Architectural Theory (3)
Arch 367 Modernism to Post-Modernism (3)
Art 195 Age of Spirituality (3)
Art 201 Archaeology: Lands of the Bible (3)
Anth 128 Urban Ethnology (3)
Anth 335 Religion, Symbolism and Cosmology (3)
Eco 311 Environmental Economics (3)
Eco 312 Urban Economics (3)
Hist 333 American Urban History to 1880 (3)
Hist 334 American Urban History, 1880 to Present (3)
Phil 123 Aesthetics (3)
Psyc 373 Sensation and Perception (3)
US 363 Philadelphia: Development of a Metropolis (3)

Architecture and Technology
Arch 147 Building Materials and Methods (3)
Arch 361 Evolution of Highrise Building Construction (3)
Arch 363 Evolution of Long Span Bridges (3)
Arch 365 Evolution of Modern Building Techniques (3)
Arch 351 CAD I (3)
Arch 352 CAD II (3)

For the architecture major, students must fulfill the mathematics requirement with Math 21 & 22; the physical science requirement must be filled with Phys 11 & 12.

For students contemplating graduate studies in architecture, Mech 2 and Mech 12 are recommended.

Undergraduate Courses in Art

Art 1. Art History I (3)
Survey of major monuments from Pyramids to Renaissance. Works seen in context of development of design concepts, relation to structural change. Slide lectures. Priester. (HU)

Art 2. Art History II (3) spring
Survey of Western painting and sculpture from Renaissance to present. Priester. (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. (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 (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, clay modeling. Emphasis on personal expression, the human figure as vehicle for narrative, abstract or formal drawings or sculpture. Gans. (HU)

Art 20. Color (3)
Projects directed toward building an awareness of color. Study and observation of the dynamics of color in theory and practice. Redd. (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)
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 and Art 8. Viera (HU)

Art 65. (Psych 65) Perception and the Visual Arts (3)
Perceptual and cognitive theories and principles as related to visual fine arts and aesthetic experience. Shortess. (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. Prerequisite: consent of the chairperson. (HU)

Art 82. (Ciss 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: departmental permission. (HU)

Art 113. Sculpture II (3)
Development of principles and techniques in Sculpture I. Modeling, casting, fabrication and carving. Emphasizes an approach to sculptural form and an exploration of the evolution of modern sculpture. Prerequisite: Sculpture I. 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 department chairman. 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, neoclassicism, the Harlem renaissance, modernism, and contemporary directions. Guest lecturers, open dialogue, gallery visits, and media presentations. Writing Intensive. Boothe. (SS)

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 includes a series of informative posters, identity systems, publication, and advertising design. Computer graphics and Macintosh lab are introduced as integral design tools in graphic design. Prerequisite: Art 53. Viera. (HU)

Art 165. (Psych 165) Perception and Visual Arts Studio (3)
Projects directed toward exploring relationships between human visual perception and the visual arts. Emphasizes visual thinking and creative problem solving. Prerequisites: Psych 65, Art 65 or consent of instructor. Shortess. (HU)

Art 174. (Arch 174, Ciss 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, Ciss 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. (HU)

Art 179. History of Photography (1)
Photography as fine art from earliest images to present day. Problems in contemporary photography. (HU)

Art 201. (Clss 201) Archaeology: Lands of the Bible (3)
Chronological survey of archaeological finds from Palaeolithic, Neolithic, Bronze Age, Iron Age, and later cultures in the Near East. Material illustrating the cultures and events of the Bible. (SS)

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 III. Boothe or Gans. (HU)

Art 218. Romanticism and Realism (2)
Painting and sculpture from late 18th-Century Romantic origins to 1860; artists such as Goya, Delacroix, Turner, Friedrich, the Hudson River School, Courbet and Daumier. (HU)

Art 220. 20th-Century Art (3)
The development of 20th-Century painting and sculpture from the foundations laid by Cezanne and Van Gogh through the revolutionary movements of cubism, expressionism, surrealism, abstract expressionism, and Pop. Illustrated lectures. Priester. (HU)

Art 221. Impressionist and Post-Impressionist Painting (2)
Liberation of color in painting; form, emotion and imagination in the Impressionist and Post-Impressionist era. (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. Boothe. (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 department chairman. (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 discussions with the instructor and respective non-profit clients, develops and conducts a minimum of two major design projects. Readings and classroom discussions of contemporary graphic design and current trends form an essential part of the course. Prerequisite: Art 153. Viera. (HU)

Art 269. Special Topics in Art History (3)
Directed projects for advanced students in the history of art or architecture. Prerequisite: consent of the department chairman. 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 the department chairman. May be repeated for credit. Staff. (ND)

Art 277. Special Topics in Photography (1-4)
Individually directed projects in photography for advanced student capable of undertaking creative work in photography. Prerequisites: Art 77, 177 and consent of department chairman. May be repeated for credit. Staff. (ND)
Art 335. Painting III (3)
Prerequisite: Art 235 or consent of the department chairman. 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, screenprinting, 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. Preapproved 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. Prerequisite: consent of department chairman. 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 potential architecture majors or minors. Composition, spatial concepts; precedent; materials and detail; light and color in architecture. Instruction in basic communication techniques. Prerequisite: Art 7. Viscardi. (ND)

Arch 103. (Clss 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/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: Arch 43. Zaknie, Corallo. (ND)

Arch 147. Building Materials and Methods
The primary structural materials - block, wood, steel and reinforced concrete - are examined in their relationship to architectural design. Peters. (ND)

Art/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)

Arch 176. (Art 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)

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, and Rome; 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 since 1750 (3)
Examination of philosophical, technological, and cultural forces shaping Western architecture and urbanism beginning with the Enlightenment. Prerequisites: Art/Arch 1 and Arch 2 or permission of instructor. 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: another course in architectural history. Zaknic. (HU)

Arch 213. The City (3)
Historical development of modern city. Philosophical, technological, and cultural forces shaping urban experience. Western culture beginning with the Enlightenment. Prerequisites: Art I or Arch I and Arch 2 or permission of instructor. May be repeated for credit as topics may vary. Thomas. (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 271. Special Topics in Architecture (1-4)
Directed projects for advanced students in architecture or architectural criticism. Prerequisites: Arch 1, 143, Art 11. Major standing in the department or consent of the department chairperson. Student must contact sponsoring professor and complete a contract sheet at preregistration. 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 methods. Prerequisite: Art 121 or Art 335 or 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 by chairman before it is pursued. (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, perceptive 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. (ND)

Arch 351. Computer Aided Design I (3)
Use and role of computers in architecture. Computer aided design (CAD) system selection and operation, geometric modeling, design knowledge. Practical CAD work on a micro-CAD system through design and drafting of architectural projects. Prerequisite: Arch 143 or consent of chairman. Anderson. (ND)

Arch 352. Computer Aided Design II (3)
Use of computer aided design as a tool to design and draft in the area of art, architecture, urban design and structures. Advanced hands on experience both early and detailed stages of design using a micro-CAD system. Prerequisite: Arch 351 or consent of chairman. Anderson. (ND)

Arch 361. (Hist 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. Peters. (HU)

Arch 363. (Hist 363) Evolution of Long-span Bridge Building (3)
New materials, forms of education and technology contributed to advance structural understanding. Specialization and the rise of technological . (HU)

Arch 365. (Hist 365) Evolution of the Modern Building Process (3)
The criteria of trade Ô time and money Ô 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. 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 II/Arch II 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 the department chairman. 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 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, Kemerer Museum of Decorative Art, Hugh Moore Park, Canal Museum. Prerequisite: Art 275. Viera. (ND)

Arts and Science

1. or 2. 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.

111. The American Character (3)
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. (ND)

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. (ND)

311. Themes in Contemporary American Civilization (3)
A required seminar open to juniors and seniors. Subject varies from semester to semester. Prerequisite: Arts 111, or permission of program director. (ND)

371. Special Topics in American Studies (1-3)
Individual study under the direction of a faculty member. May be repeated for credit. Permission of program director required. (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 Science. An Arts-Engineering graduate is awarded two Bachelor degrees, one from the College of Arts and Science 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)**

<table>
<thead>
<tr>
<th>Arts &amp; Sciences</th>
<th>Choices &amp; Decisions</th>
<th>(P/F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>English 1</td>
<td>Composition/Literature</td>
<td>3</td>
</tr>
<tr>
<td>Math 21</td>
<td>Analyt Geom and Calc 1</td>
<td>4</td>
</tr>
<tr>
<td>Chemistry 21</td>
<td>Intro Chemical Principles</td>
<td>4</td>
</tr>
<tr>
<td>Chemistry 22</td>
<td>Intro Chem Princ Lab</td>
<td>1</td>
</tr>
<tr>
<td>(Dept) 90</td>
<td>College Seminar</td>
<td>3</td>
</tr>
</tbody>
</table>

**freshman year, second semester (16 credit hours)**

| Engineering 1   | Engineering computations | 3     |
| Engineering 2   | Intro to Engineering | 1     |

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 Science 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 Science 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 science, and math) 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 College of Arts and Science. When selected properly, courses which meet distribution requirements in the College of Arts and Science will also satisfy most distribution requirements of the College of Engineering and Applied Science.

**Arts-Chemical Engineering**

A total of 166 credit hours is needed for the bachelor of arts and the bachelor of science degree.

See electives (b) through (f) for the chemical engineering program on page 33. 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.

<table>
<thead>
<tr>
<th>Sophomore year, first semester (16 credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChE 31 Material and Energy Balances of Chemical Processes (3)</td>
</tr>
<tr>
<td>Chm 31 Chemical Equilibria in Aqueous Solutions (3)</td>
</tr>
<tr>
<td>Math 23 Analytic Geometry and Calculus III (4)</td>
</tr>
<tr>
<td>AS courses/electives (6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sophomore year, second semester (18 credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChE 44 Fluid Mechanics (4)</td>
</tr>
<tr>
<td>Phy 21 Introductory Physics II (4)</td>
</tr>
<tr>
<td>Phy 22 Introductory Physics II Laboratory (1)</td>
</tr>
<tr>
<td>Chm 187 Physical Chemistry I (3)</td>
</tr>
<tr>
<td>Math 205 Linear Methods (3)</td>
</tr>
<tr>
<td>AS courses/electives (3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Junior year, first semester (18 credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChE 151 Introduction to Heat Transfer (3)</td>
</tr>
<tr>
<td>Chm 51 Organic Chemistry I (3)</td>
</tr>
<tr>
<td>Chm 53 Organic Chemistry Laboratory I (1)</td>
</tr>
<tr>
<td>Chm 192 Physical Chemistry Laboratory (2)</td>
</tr>
<tr>
<td>AS courses/electives (9)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Junior year, second semester (17 credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChE 244 Mass Transfer and Separation Processes (3)</td>
</tr>
<tr>
<td>ChE 210 Chemical Engineering Thermodynamics (4)</td>
</tr>
<tr>
<td>ChE 179 Professional Development (1)</td>
</tr>
<tr>
<td>Chm 52 Organic Chemistry II (3)</td>
</tr>
<tr>
<td>AS courses/electives (6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Senior year, first semester (18 credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChE 201 Methods of Analysis in Chemical Engineering (3)</td>
</tr>
<tr>
<td>Chm 189 Physical Chemistry II (3)</td>
</tr>
<tr>
<td>electives for engineering major (6)*</td>
</tr>
<tr>
<td>AS courses/electives (6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Senior year, second semester (18 credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChE 211 Chemical Reactor Design (3)</td>
</tr>
<tr>
<td>ChE 242 Introduction to Process Control and Simulation (3)</td>
</tr>
<tr>
<td>electives for engineering major (6)*</td>
</tr>
<tr>
<td>AS courses/electives (6)</td>
</tr>
</tbody>
</table>

**Arts-Civil Engineering**

A total of 162 credit hours is needed for the bachelor of arts and the bachelor of science degrees.

<table>
<thead>
<tr>
<th>Sophomore year, first semester (16 credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 23 Analytic Geometry and Calculus III (4)</td>
</tr>
<tr>
<td>Mech 2 Elementary Engineering Mechanics (3)</td>
</tr>
<tr>
<td>EES 101 Geology for Engineers (3)</td>
</tr>
<tr>
<td>AS courses/electives (6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sophomore year, second semester (17 credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 205 Linear Methods (3)</td>
</tr>
<tr>
<td>Mech 12 Strength of Materials (3)</td>
</tr>
<tr>
<td>Phy 21 Introductory Physics II (4)</td>
</tr>
<tr>
<td>Phy 22 Introductory Physics Laboratory II (1)</td>
</tr>
<tr>
<td>CE 15 Graphics for Civil Engineering (3)</td>
</tr>
<tr>
<td>AS courses/electives (6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Junior year, first semester (16 credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mat 192 Structural Materials (3)</td>
</tr>
<tr>
<td>CE 14 Measurements and Problem Solving in Civil Engineering (4)</td>
</tr>
<tr>
<td>CE 121 Mechanics of Fluids (3)</td>
</tr>
<tr>
<td>*Engineering Science Elective (3)</td>
</tr>
<tr>
<td>AS courses/electives (9)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Junior year, second semester (15 credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 117 Numerical Methods in Civil Engineering (2)</td>
</tr>
<tr>
<td>CE 222 Hydraulic Engineering (4)</td>
</tr>
<tr>
<td>Eco 11 or 12 Principles of Micro- or Macroeconomics (3)</td>
</tr>
<tr>
<td>AS courses/electives (6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Senior year, first semester (17 credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 143 Soil Mechanics (4)</td>
</tr>
<tr>
<td>Course Code</td>
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</tr>
<tr>
<td>CE 159</td>
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<tr>
<td>CE 160</td>
</tr>
<tr>
<td>CE 270</td>
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</tr>
</tbody>
</table>

**Senior Year, First Semester** (14 credit hours)

- ECE 121 Electronic Circuits Laboratory (2)
- ECE 123 Electronic Circuits (3)
- CSc 262 Programming Languages (3)
- AS courses/electives (6)

**Senior Year, Second Semester** (14 credit hours)

- ECE 138 Digital Systems Laboratory (2)
- ECE 201 Computer Architecture (3)
- approved technical elective* (3)
- AS courses/electives (6)

**Fifth Year** (36 credit hours)

See program description for senior year of computer engineering, page 204.

*These electives require approval of the department of computer science and electrical engineering. They are subjects in the area of engineering science and design not restricted to offerings of the department.

### Arts-Electrical Engineering

A total of 159 credit hours is needed for the bachelor of arts and bachelor of science degrees.

**Sophomore Year, First Semester** (15 credit hours)

- Math 23 Analytic Geometry and Calculus III (4)
- Phy 21 Introductory Physics II (4)
- Phy 22 Introductory Physics Laboratory II (1)
- CSc 17 Structured Programming and Data Structures (4)
- CSc 261 Discrete Structures (3)
- Math 205 Linear Methods (3)
- AS courses/electives (6)

**Sophomore Year, Second Semester** (15 credit hours)

- ECE 81 Principles of Electrical Engineering (4)
- ECE 33 Introduction to Computer Engineering (4)
- Math 205 Linear Methods (3)
- approved elective* (3)
- AS courses/electives (9)

**Junior Year, First Semester** (17 credit hours)

- ECE 108 Signals and Systems (4)
- Math 231 Probability and Statistics (3)
- Math 309 Theory of Probability (3)
- AS courses/electives (9)

**Junior Year, Second Semester** (17 credit hours)

- ECE 108 Signals and Systems (4)
- Math 231 Probability and Statistics (3)
- ECE 82 Sophomore Laboratory (1)
- ECE 116 Software Engineering (3)
- ECE 108 Signals and Systems (4)
- ECE 82 Sophomore Laboratory (1)
- AS courses/electives (9)

**Junior Year, First Semester** (14 credit hours)

- ECE 121 Electronic Circuits Laboratory (2)
- ECE 123 Electronic Circuits (3)
- ECE 125 Circuits and Systems (3)
- approved elective* (3)
- AS courses/electives (3)
**Descriptions of Courses**

**senior year, second semester** (17 credit hours)
ECE 126 Physical Electronics (3)
ECE 136 Electromechanics (3)
ECE 138 Digital Systems Laboratory (2)
ECE 202 Introduction to Electromagnetics (3)
approved technical elective* (3)
AS courses/electives (3)

**fifth year** (36 credit hours)

See program description for senior year of electrical engineering, page 203.

*These electives require approval of the department of computer science and electrical engineering. Approved electives are subjects predominantly in the area of engineering science and design. They are not restricted to offerings in the department. Students must choose at least one elective in either materials, thermodynamics, fluid mechanics, or physical chemistry, and at least one elective in physics, chemistry, or biology.

**Arts-Engineering Physics**
A total of 157 credit hours is needed for the bachelor of arts and bachelor of science degrees. For the freshman year, see page 33.

**sophomore year, first semester** (16 credit hours)
Phy 21 Introductory Physics II (4)
Phy 22 Introductory Physics Laboratory II (1)
Math 23 Analytic Geometry and Calculus III (4)
AS courses/electives (7)

**sophomore year, second semester** (15 credit hours)
Phy 31 Introduction to Quantum Mechanics (3)
Math 205 Linear Methods (3)
AS courses/electives (9)

**junior year, first semester** (16 credit hours)
Phy 212 Electricity and Magnetism I (3)
Phy 215 Classical Mechanics I (4)
Math 322 Methods of Applied Analysis I (3)
AS courses/electives (3)*

**junior year, second semester** (15 credit hours)
Phy 213 Electricity and Magnetism II (3)
Phy 190 Electronics (3)
Phy 362 Atomic and Molecular Structure (3)
AS courses/electives (3)*

**senior year, first semester** (17 credit hours)
Phy 260 Laboratory Techniques (2)

**junior year, second semester** (15 credit hours)
Phy 261 Optics, Spectroscopy, and Quantum Physics Laboratory (2)
Phy 264 Nuclear and Elementary Particle Physics (3)
AS courses/electives (6)

**fifth year, first semester** (15 credit hours)
Phy 340 Thermal Physics (3)
AS courses/electives (12)

**fifth year, second semester** (15 credit hours)
Phy 171 Physics Proseminar (1)
AS courses/electives (14)

*The electives include at least fourteen credit hours of approved technical electives, including two of the courses Phy 363, 369, (352 or 355), and (346 or 348 or 365). Students planning graduate work in physics are advised to include Phy 273 and 369 among their electives.

**Arts-Industrial Engineering**
A total of 159 credit hours is needed for the bachelor of arts and bachelor of science degrees.

**sophomore year, first semester** (16 credit hours)
Math 23 Analytic Geometry and Calculus III (4)
Phy 21 Introductory Physics II (4)
Phy 22 Introductory Physics Laboratory II (1)
IE 111 Engineering Probability and Statistics (3)
IE 112 Computer Graphics (1)
AS courses/elective (3)

**sophomore year, second semester** (16 credit hours)
IE 121 Applied Engineering Statistics (3)
IE 122 Software Tools (1)
IE 124 Engineering Economy and Decision Analysis (3)
AS courses/electives (9)

**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** (16 credit hours)
IE 115 Fundamentals of Modern Manufacturing (3)
IE 116 Manufacturing Laboratory (1)
Mech 2 Elementary Engineering Mechanics (3) AS courses/electives (9)

**Senior year, second semester** (16 credit hours)
IE 131 Work Systems and Facilities Planning (3)
IE 132 Work Systems and Facilities Planning Laboratory (1)
ME 104 Thermodynamics (3) IE elective (3)* AS courses/electives (6)

**Summer**
IE 100 Industrial Employment (0)

**Fifth year**

See program description for senior year of Industrial Engineering, page 33.

*Note: IE electives must be approved by the department of industrial engineering adviser.

**Arts-Mechanical Engineering**
A total of 158 credit hours is needed for the bachelor of arts and the bachelor of science degrees.

**Sophomore year, first semester** (16 credit hours)
Phy 21 Introductory Physics II (4) Phy 22 Introductory Physics Laboratory II (1)
Math 23 Analytic Geometry and Calculus III (4) ME 10 Graphics for Engineering Design (4) AS courses/electives (3)

**Sophomore 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)

**Junior year, first semester** (16 credit hours)
Mech 12 Strength of Materials (3) ME 105 Thermodynamics II (3) ECE 81 Principles of Electrical Engineering (4) AS courses/electives (6)

**Junior year, second semester** (14 credit hours)
Mech 102 Dynamics (3)

ME 21 Mechanical Engineering Laboratory I (1)
ME 231 Fluid Mechanics (3) ECE 162 Electrical Engineering Laboratory (1) AS courses/electives (6)

**Senior year, first semester** (16 credit hours)
ME 111 Professional Development (1) Mat 33 Engineering Materials and Processes (3) Math 208 Complex Variables (3) or Math 231 Probability and Statistics (3) ME 252 Mechanical Elements (3) AS courses/electives (6)

**Senior year, second semester** (15 credit hours)
ME 101 Mechanical Engineering Design I (2) ME 242 Mechanical Vibrations (3) ME 240 Manufacturing (3) ME 121 Mechanical Engineering Laboratory II (1) AS courses/electives (6)

**Fifth year**

See program description for senior year of mechanical engineering & mechanics, page 288.

**Arts-Materials Science and Engineering**
A total of 161 to 163 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 Analytic Geometry and Calculus III (4) Phy 21 & 22 Introductory Physics II and Laboratory (5) Mat 10 Materials Laboratory (1) AS courses/elective (3)

**Sophomore year, second semester** (15 credit hours)

**Junior year, first semester** (15 credit hours)
Chem 209 Chemistry of Materials (3) Mat 216 Diffusion and Phase Transformations (3) Mat 218 Mechanical Behavior of Materials (3) AS courses/electives (6)
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)
AS courses/electives (18)

senior year, second semester (15 credit hours)
ECE 81 Principles of electrical Engineering (4)
Mat 101 Professional Development (2)
AS courses/electives (6)

fifth year

See program description for senior year of materials science and engineering, page 272.

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-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


Associate professors. Kenneth Kraft, Ph.D. (Princeton), Religion Studies; David Pankenier, Ph.D. (Stanford), Modern Foreign Languages; Nicola Tannenbaum, Ph.D. (Iowa), Social Relations.

Assistant professors. Constance Cook, Ph.D. (U.C., Berkeley), Modern Foreign Languages; Gill Cooper, Ph.D. (U.C., Santa Barbara), History; Kiri Lee, Ph.D. (Harvard), Modern Foreign Languages.

The Asian studies program affords undergraduates in any college within Lehigh an opportunity to acquire a systematic knowledge of Asia, broadly defined, i.e., China, Japan, Korea, Southeast Asia and the Pacific. The program encompasses 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.

The major in Asian studies may have a Chinese studies or a Japanese studies concentration, each requiring a minimum of 35 credits. Chinese or Japanese language to intermediate level (2 years) is required, in addition to other courses in the humanities and social sciences. The major is based on an approved list of courses in Asian studies, chosen in consultation with the major advisor, Professor David Pankenier, Modern Foreign Languages, 515 Maginnes Hall, 758-3090.

The minor in Asian studies is composed of a minimum of 15 credits in Asian studies, chosen from an approved list in consultation with the minor advisor, Professor Constance Cook, Modern Foreign Languages, 519 Maginnes Hall, 758-3091.

Additional courses are offered at other LVAIC 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.

Students are encouraged to spend a summer, semester or year abroad in an approved study program in China, Japan, Korea, Southeast Asia or the Pacific. Subject to prior approval, credits acquired abroad can be transferred back to Lehigh. For details on various programs currently available, consult, Cas Sowa, Study Abroad Coordinator, International Education Office, 344 Whitaker Laboratory, 758-3351.

The program cooperates with the LVAIC Asia Seminar, which meets four times a year (twice a semester) to discuss current research in various fields. While the seminar primarily involves faculty, Asian studies majors and minors are also encouraged to participate. The seminar coordinator is Professor Nicola Tannenbaum, Social Relations, 11 Price Hall, 758-3829.

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 some aspect 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 Professor Raymond Wylie, Director, Asian Studies Program, 208 Maginnes Hall, 758-3389/3390 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 language and 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., 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 11 courses (35 credits). The distribution of the credits is as follows, subject to the guidance of the academic advisor, Professor David Pankenier, Modern Foreign Languages, 515 Maginnes Hall, 758-3090. Full descriptions of all Asian studies courses are provided in the listings of individual departments.

I. Core Requirements

A. Language and Culture: Chinese or Japanese to intermediate level (2 years); 4 courses (14 credits), variable, 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) HU</td>
<td>4</td>
</tr>
<tr>
<td>Chin 2</td>
<td>Elementary Chinese I (4) HU</td>
<td>4</td>
</tr>
<tr>
<td>Chin 11</td>
<td>Intermediate Chinese I (3) HU</td>
<td>3</td>
</tr>
<tr>
<td>Chin 12</td>
<td>Intermediate Chinese II (3) HU</td>
<td>3</td>
</tr>
<tr>
<td>Chin 91</td>
<td>Elementary Chinese Language and Culture Abroad</td>
<td>1-6</td>
</tr>
<tr>
<td>Chin 191</td>
<td>Intermediate Chinese Language and Culture Abroad</td>
<td>1-6</td>
</tr>
<tr>
<td>Jpns 1</td>
<td>Elementary Japanese I (4) HU</td>
<td>4</td>
</tr>
<tr>
<td>Jpns 2</td>
<td>Elementary Japanese II (4) HU</td>
<td>4</td>
</tr>
<tr>
<td>Jpns 11</td>
<td>Intermediate Japanese I (3) HU</td>
<td>3</td>
</tr>
<tr>
<td>Jpns 12</td>
<td>Intermediate Japanese II (3) HU</td>
<td>3</td>
</tr>
<tr>
<td>Jpns 91</td>
<td>Elementary Japanese Language and Culture Abroad</td>
<td>1-6</td>
</tr>
<tr>
<td>Jpns 191</td>
<td>Intermediate Japanese Language and Culture Abroad</td>
<td>1-6</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 35 credit hours.

B. Humanities: 2 courses (6 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 72</td>
<td>Chinese Literature in Translation (3) HU</td>
<td>3</td>
</tr>
<tr>
<td>Asia 74</td>
<td>Chinese Cultural Program (3-6) HU</td>
<td></td>
</tr>
<tr>
<td>Asia 75</td>
<td>Chinese Civilization (3) HU/SS</td>
<td></td>
</tr>
<tr>
<td>Asia 62</td>
<td>Religions of India (3) HU</td>
<td>3</td>
</tr>
<tr>
<td>Asia 64</td>
<td>Religions of China (3) HU</td>
<td>3</td>
</tr>
<tr>
<td>Asia 65</td>
<td>Religions of Japan (3) HU</td>
<td>3</td>
</tr>
</tbody>
</table>

II. Advanced Electives

Two courses (6 credits) chosen from the following, 1 course (3 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 (3) HU</td>
<td>3</td>
</tr>
<tr>
<td>Chin 142</td>
<td>Advanced Chinese II (3) HU</td>
<td>3</td>
</tr>
<tr>
<td>Chin 151</td>
<td>Modern Chinese Fiction (3) HU</td>
<td>3</td>
</tr>
<tr>
<td>Chin 291</td>
<td>Advanced Chinese Language and Culture Abroad (1-6) HU</td>
<td>1-6</td>
</tr>
<tr>
<td>Jpns 371</td>
<td>Special topics (1-3) HU</td>
<td>1-3</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 (3) HU</td>
<td>3</td>
</tr>
<tr>
<td>Asia 361</td>
<td>Internship in Asian Studies (1-3) ND</td>
<td>1-3</td>
</tr>
<tr>
<td>Asia 364</td>
<td>Seminar in the International Relations of East Asia/Pacific Rim (3) SS</td>
<td>3</td>
</tr>
<tr>
<td>Asia 371</td>
<td>Advanced Readings in Asian Studies (3) HU/SS</td>
<td></td>
</tr>
<tr>
<td>Asia 381</td>
<td>Special Topics in Asian Studies (3) HU/SS</td>
<td></td>
</tr>
<tr>
<td>Asia 391</td>
<td>Senior Seminar in Asian Studies (3) HU/SS</td>
<td></td>
</tr>
</tbody>
</table>

D. Other suitable courses at LVAIC or other approved institutions in the United States.

E. Other suitable courses in approved study abroad programs in East Asia.
Minor in Asian Studies
The minor in East 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 5 courses (15 credits) in East Asian studies, chosen from an approved list in consultation with the minor advisor, Professor Constance Cook, Modern Foreign Languages, 519 Maginnes Hall, 758-3091.

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 appeal to the Study Abroad Committee 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 Dr. Cas Sowa, Lehigh Abroad coordinator, International Education Office, 344 Whitaker Laboratory, 758-3351.

Asian Studies Courses Not Crosslisted Elsewhere in the Catalogue
ASIA 361. Internship in Asian Studies (1-3) ND
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.

ASIA 371. Advanced Readings in Asian Studies (3) ND
Directed course of reading and writing in advanced topics not covered in regular Asian studies course offerings. May be repeated for credit. Program permission required.

ASIA 381. Special Topics in Asian Studies (3) ND
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.

ASIA 391. Senior Seminar in Asian Studies (3) ND
Advanced seminar focusing on discussion and research on specialized subjects in Asian studies. Variable subject matter. Offered by faculty on rotating basis. May be repeated for credit. Program permission required.

ASIA 399. Senior Thesis in Asian Studies (3) HU/S.S.
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.

Astronomy
Professor. George E. McCluskey, Ph.D. (Pennsylvania), head.
Astronomy is offered in the department of mathematics.

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 meteoroids; origin of the solar system; the Sun. (NS)

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)

171. Readings (1-3) fall-spring
For nonscience majors to study an area of astronomy more deeply than at the introductory level. Individual supervision. Prerequisites: Astr 1 or Astr 2, and Math 21 or Math 31 or Math 41. May be repeated for credit with the consent of the division head.

211. Stellar Structure and Evolution (3) fall, even-numbered years

212. Stellar Atmospheres (3) fall, odd-numbered years
Observation and theory of stellar spectra. Model atmospheres and chemical abundances. Extended atmospheres, stellar winds and mass loss. Theory of gaseous nebulae. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21. (NS)

332. (Phys 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 Math 32 or Math 44, previously or concurrently, and Phys 21. (NS)

342. (Phys 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 Math 32 or Math 44, previously or concurrently, and Phys 21. (NS)
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 32. 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 (Alhadeff, Rebe, Lowe-Krentz, and Schrty), 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 page 45 of current catalog) (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 (2)
Math 23 Analytic Geometry and Calculus III (4)
modern foreign language requirement (3)*
*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 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; 3. Substitutions of six credits of science electives. If science electives are chosen, non-science distribution requirements must still be met.

*Chm 58 Organic Chemistry Lab II (1)
Chm 187 Physical Chemistry I (3)
Math 205 Linear Methods (3)
modern foreign language requirement (3)
biological science elective (3)

*Junior year, first semester* (16 credit hours)
Chm 324 Analytical Chemistry Lab (1)
Chm 332 Analytical Chemistry (3)
BioS 371 Elem. of Biochemistry I (3)
BioS 377 Biochem. Lab (3)
Eco 11 or 12 Economics (3)
 Humanities/Social Science requirement (3)

*Junior year, second semester* (17 credit hours)
BioS 372 Elem. of Biochemistry II (3)
Chm 353 Organic Analysis Lab (3)
Chm 201 Technical Writing (2)
 Humanities/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)
 Biological sciences elective (3)
 Humanities/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 18
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**

1. **College and University Requirements** 28 hours
   a. English 1, 2 6 hours
b. Arts and Science I: 1 hour

c. First Year Seminar: 3 hours

d. Non-science electives: 18 hours to be broadly distributed in fields of thought other than natural science and mathematics, including at least 9 hours each in humanities and social sciences.

II. Collateral Science Requirements: at least 24 hours

a. Physics 11, 12, 13, 14 (or 21, 22): 9 (or 10 hours)

b. Mathematics 41, 43, 44 (or 21, 22, 23) and a statistics course: at least 12 hours

c. Computer Science 11 or Engineering I: 3 hours

III. Required Chemistry Courses: 25 to 26 hours

a. Introductory Chemistry: Chemistry 75, 76: 8 hours*
b. Organic Chemistry: Chemistry 51, 52, 53, 58: 8 hours

c. Inorganic Chemistry: Chemistry 205 or 307: 2 or 3 hours

d. Physical Chemistry: Chemistry 187 or 194: 3 hours

e. Analytical Chemistry: Chemistry 234, 332: 4 hours

*The Chemistry 21/22/31 sequence may be substituted.

IV. Required Biological Science courses: 24 hours


b. Introduction to Molecular and Cellular Biology: 31, 32: 4 hours

c. Advanced Laboratory: 3 hours

d. Electives in Biological Sciences: 6 hours minimum*
f. 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 41, 44: BMSS Calculus I and II (6) or

Math 21, 22: Calculus I and II (8)

FS 90: College Seminar (3)

A&S 1: Choices & Decisions (1)

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

BioS 110: Experimental Design and Statistical Analysis

Chm 187 Physical Chemistry (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 234 Analytical Chemistry Lab (1)

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 Structured Programming (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

BioS elective
Biological Sciences

Professors, Ph.D. (Rutgers), chairperson:
John H. Abel, Ph.D. (Brown); Dave Cundall, Ph.D. (Arkansas); Murray Itzkowitz, Ph.D. (Maryland); Steven Krawiec, Ph.D. (Yale); Jeffrey A. Sands, Ph.D. (Penn State).

Associate professors. Barry Bean, Ph.D. (Rockefeller); Michael J. Behe, Ph.D. (Pennsylvania); Michael R. Kuchka, Ph.D. (Carnegie-Mellon); Linda J. Lowe-Krentz, Ph.D. (Northwestern); Jill Schneider, Ph.D. (Wesleyan); Vassie C. Ware, Ph.D. (Yale).

Assistant professors. Agnes Ayme-Southgate, Ph.D. (Geneva); Lynne Cassimeris, Ph.D. (North Carolina).

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). The Biochemistry degree programs are described in a section on page 119.

The requirements for the B.A. and B.S. in Biology, Behavioral Neuroscience, and Molecular Biology are listed below.

B.A. with Major in Biology
College and university requirements (28 credit hours)
Eng 1 Composition and Literature (6)
A&S 1 Choices and Decisions (1)
First Year Seminar (3)
Social Sciences (9)
Humanities (9)

Major Program (30 credit hours)

<table>
<thead>
<tr>
<th>Biology (30 credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EES 31 Intro. to Environmental and Organismal Biology (3)</td>
</tr>
<tr>
<td>EES 32 Lab Intro. Environmental/Organismal Biology (1)</td>
</tr>
<tr>
<td>BioS 31 Intro. to Cell and Molecular Biology (3)</td>
</tr>
<tr>
<td>BioS 32 Intro. Cell/Molecular Laboratory (1)</td>
</tr>
<tr>
<td>BioS 101 Genetics (3)</td>
</tr>
<tr>
<td>BioS 102 Genetics Laboratory (1)</td>
</tr>
<tr>
<td>Electives Biology approved electives (18 credit hours)</td>
</tr>
</tbody>
</table>

Mathematics (6 credit hours)
Math 41 BMSS Calculus I (3)*
Math 44 BMSS 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) or
Chm 194 Physical Chemistry for Biological Sciences (3) or
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 (28 credit hours)
Eng 1 Composition and Literature (6)
A&S 1 Choices and Decisions (1)
First Year Seminar (3)
Social Sciences (9)
Humanities (9)

Major Program (84 credit hours)

<table>
<thead>
<tr>
<th>Biology (35 credit hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EES 31 Intro. to Environmental/Organismal Biology (3)</td>
</tr>
<tr>
<td>EES 32 Lab Intro. Environmental/Organismal Biology (1)</td>
</tr>
<tr>
<td>BioS 31 Intro. to Cell and Molecular Biology (3)</td>
</tr>
<tr>
<td>BioS 32 Intro. Cell and Molecular Biology Laboratory (1)</td>
</tr>
<tr>
<td>BioS 101 Genetics (3)</td>
</tr>
<tr>
<td>BioS 102 Genetics Laboratory (1)</td>
</tr>
</tbody>
</table>

one of the following:
EES 162 Non-Vascular Plants (3) or
EES 163 Evolution of Vascular Plants (3) or
BioS 134 Comparative Vertebrate Anatomy (4)

and
EES 251, 252 Ecology and Laboratory (4)
BioS 317 Evolution (3)

and one of the following:
EES 361, 362 Animal Physiology and Laboratory (4) or
Descriptive of Courses

BioS 324, 325
Electives
Bacteriology and Laboratory (4)
Biology electives (9)

Mathematics (12 credit hours)
either
Math 21, 22, 23
Analytic Geometry and Calculus I, II, III (12)
or
Math 41, 43, 44
BMSS Calculus I, II and
Linear Algebra (9)
and
Math 6, 12 or
231
Intro. to Probability (3), Statistical
Methods (3), or Probability and
Statistics (3)

Collateral Sciences (37 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 I and II
(2)
Chm 31
Chemical Equilibria in Aqueous
Systems (3)
Chm 187 or 194
Physical Chemistry I (3)
Phy 11
Introductory Physics I (4)
Phy 12
Introductory Physics Laboratory I (1)
Phy 13
Introductory Physics II-B (3)
Phy 14
Intro. Physics Lab II-B (1)
EES 21 or 11
Intro to Earth Materials & Processes (4)
or Environmental Geology (3)
elective
any course in the natural sciences or
mathematics (3)
and one of the following:
Psyc 1
Introduction to Psychology (3)
BioS 110
Experimental Design and Statistical
Analysis (3)
Phil 128
Philosophy of Science (3)

Recommended B.S. Biology Sequence
freshman year
EES 31
Intro. to Environmental/Organismal
Biology (3)
EES 32
Lab Intro. Environmental/Organismal
Biology (1)
BioS 31
Intro. to Cell and Molecular Biology (3)
BioS 32
Intro. Cell/Molecular Laboratory (1)
Math 21, 22
Analytic Geometry and
Calculus I and II or
Math 41, 44
BMSS Calculus I and II (6)
Chm 21, 22
Introductory Chemical Principles and
Laboratory (5)
FS 90
First Year Seminar (3)
A&S 1
Choices & Decisions (1)
sophomore year
BioS 101
Genetics (3)
BioS 102
Genetics Laboratory (1)
Chm 31, 51, 52, 53, 58
Organic Chemistry and Laboratory (8)
Math 23
Analytic Geometry and Calculus III (4)
or
Math 43
Math 6, 12
or 231;
Probability and Linear Algebra (6)
one of the following:
EES 131
Non-vascular Plants (3) or
EES 132
Evolution of Vascular Plants (3) or
BioS 134
Comparative Vertebrate Anatomy (4)
elective
Psyc 1, Introduction to Psychology (3)
or BioS 110, Experimental Design and
Statistical Analysis (3) or Phil 128,
Philosophy of Science (3)

described year
EES 21 or 11
Intro to Earth Materials & Processes (4)
or Environmental Geology (3)
Phy 11, 12
Introductory Physics I and
Laboratory (5)
Phy 13, 14
Introductory Physics II-B and
Laboratory (4)
EES 251, 252
Ecology and Laboratory (4)
one of the following:
EES 361, 362
Animal Physiology and Laboratory (4)
or
BioS 324,
Bacteriology and Laboratory (4)

senior year
Chm 31
Chemical Equilibria in Aqueous
Systems (3)
Chm 187 or 194
Physical Chemistry I (3)
BioS 317
Evolution (3)
elective
Biol electives (6)
elective
natural sciences (3)
Minor in Biology
A minor in biology may be achieved by completing the following requirements (26 credits):
EES 31, 32 Intro. to Environmental/Organismal Biology and Laboratory (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 41 BMSS Calculus I (3)
Elective Biology electives (3)

B.A. in Behavioral Neuroscience
The B.A. in Behavioral Neuroscience is a natural science major for B.A. distribution purposes.

Required Major Courses
Core Courses
Psyc 1 Introduction to Psychology (4)
EES 31 Introduction to Environmental and Organismal Biology (3) or
BioS 51 Introduction to the Vertebrates (4)
BioS 31 Introduction to Cell and Molecular Biology (3)
Anth 12 Human Evolution and Prehistory (3)
BioS 101 Genetics (3)
BioS/Psyc 110 Experimental Design and Statistical Analysis (3)
Psyc 210 Experimental Psychology (4) or
BioS/Psyc 277 Experimental Neuroscience Laboratory (4)
Psyc 177 Introduction to Behavioral Neuroscience (3)
EES 32 Introduction to Environmental and Organismal Biology Laboratory (1) or
BioS 32 Introduction to Cell and Molecular Biology Laboratory (1)

Category 1: take one course
BioS/Psyc 335 Animal Behavior (3)
BioS/Psyc 337 Sociobiology (3)

Category 2: take one course
BioS/Psyc 375 Neuroanatomy of Behavior (3)
BioS/Psyc 382 Endocrinology of Behavior (3)

Category 3: six credits (major electives)
BioS 134 Comparative Vertebrate Anatomy (4)
BioS 151 Vertebrate Field Biology (3)
BioS 313 General Histology (3)
BioS 314 Developmental Biology (3)
BioS 317 Evolution (3)
BioS 373 Sensation and Perception (3)
Psyc 77 Drugs and Behavior (3)
Psyc 117 Cognitive Psychology (3)
Psyc 153 Personality (3)
Psyc 154 Introduction to Clinical Psychology (3)
Psyc 171 Learning Processes and Applications (3)
Psyc 176 Mind and Brain (3)
Psyc 305 Abnormal Psychology (3)
Psyc 307 Seminar in Cognition (3)
Psyc 377 Seminar in Physiological Psychology (3)
BioS 221 Human Histology (3)
BioS 229 Immunology (3)
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)
EES 361 Animal Physiology (3)
Chm 31 Chemical Equilibria in Aqueous Systems (3)
BioS 371 Elements of Biochemistry I (3)
BioS 372 Elements of Biochemistry II (3)
BioS 377 Biochemistry Laboratory (3)

Or courses remaining in categories 1 and 2 (above).

Required Courses in Math and Chemistry
Math 41, 44 BMSS Calculus I and II (6) or
Math 21, 22 Calculus I and II (8)
Chm 21 Introductory Chemical Principles (4)
Chm 22 Chemical Principles Laboratory (1)
Chm 51, 52 Organic Chemistry (6)
Chm 53, 58 Organic Chemistry Laboratory I and II (2)

Other Options
The B.A. in Behavioral Neuroscience is a traditional liberal arts degree which can be structured for a wide variety of possibilities (see listing of recommended elective courses). By using free electives to take additional math and science, the B.A. also can serve as a preprofessional degree for many graduate and professional schools. Students interested in a particular career-based program should consult their advisor or the program director (Professor John Nyby).

B.S. in Behavioral Neuroscience
B.S. majors are required to take the core courses and all of the courses listed in category 1 and category 2 of the B.A. program and to fulfill the elective requirements of category 3 of the B.A. program. An early commitment to the B.S. is desirable to meet all the requirements of this program. Additional requirements are shown below.

Math and science requirements for the B.S.
Math 21, 22, 23 Calculus I, II & III (12)
Chm 21, 22 Introductory Chemical Principles & Lab (5)
Chm 51, 52 Organic Chemistry I & II (6)
Chm 53, 58 Organic Chemistry Laboratory (2)
BioS 371 Elements of Biochemistry I & II (6)
9 Descriptions of Courses

372
BioS 377 Biochemistry Laboratory (3)
Phy 11, 12 Introductory Physics and Laboratory (5)
Phy 13, 14 General Physics and Laboratory (4)
Phy 21, 22 (5) can substitute for Phy 13, 14.

University and College requirements for the B.S.
Engl 1 Composition and Literature (3)
Engl 2, 4, 6, 8 or 10 Composition and Literature (3)
A&S 1 Choices and Decisions (1)
First Year Seminar (3)

Nonscience Electives (18) to be broadly distributed in fields of thought other than the natural sciences and mathematics, including at least 9 credit hours each in the humanities and social sciences.

Requirements for the B.A. in Molecular Biology
College and University requirements (see page 32 of University catalog).
A. A&S 1, Choices and Decisions 1 credit
B. College Seminar 3 credits
C. English composition 6 credits
D. Mathematical sciences 3-4 credits*
E. Sciences 9-10 credits
F. Social sciences 9-10 credits
G. Humanities 9-12 credits+

The BA in Molecular Biology
Molecular biology (28 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 (1)
BioS (Chm) 371 Biochemistry (3)
BioS 345, 346 Molecular Genetics (3) and Lab (1)
BioS 367 Cell Biology (3)
BioS electives (6 credit hours)

Mathematics (8-9 credit hours)
Math 21 and 22 (8) Calculus or
Math 41, 43 and 44 (9) Calculus

Chemistry (13 credit hours)
Chm 21, 22 Introduction to Chemical Principles (3) and Lab (1)
Chm 51, 52, 53, 58 Organic Chemistry and Lab (8)

Physics (5 credit hours)
Phy 11, 12 Introductory Physics and Lab (5)

Physics/chemistry elective (3 or 4 credit hours)

Chm 31 or Chemistry Equilibria (3)
Chm 194 or Physical Chemistry (3)
Phy 13, 14 Introductory Physics II and Lab (4)

Philosophy (3 credit hours)
Phil 128 Philosophy of Science (3)

Natural science, mathematics, or computing science (3 credit hours)
*The mathematics distribution requirement is satisfied by courses required in the major.
*The science 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 (28 credit hours)
Engl 1 Composition and Literature (3)
Engl 2, 4, 6, 8, 10 Composition and Literature (3)
A&S 1 Choices and Decisions (1)
First Year Seminar (3)

Non-science electives (18), to be broadly distributed in fields of thought other than natural sciences and mathematics, including 9 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)
or
Math 41, 43, 44 and one of Math 6, 12, or 231 (12 credit total)

Chemistry (19 credit hours)
Chm 21, 22 Chemical Principles Laboratory (1)
Chm 51, 52 Organic Chemistry (6)
Chm 53, 58 Organic Chemistry Laboratory (2)
Chm 31, 194 Chemical Equilibria in Aqueous (or 187) 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) Introductory Physics II (3 or 4)
Phy 14 (or 22) Introductory Physics Lab II (1)

Natural sciences, mathematics or computing science (6 credit hours)
electives (6)
Free electives (12 credit hours)

Molecular Biology (35-37 credit hours)
BioS 31 Intro. to Cell and Molecular Biology (3)
BioS 32 Intro. to Cell and Molecular Biology Laboratory (1)
BioS 101 Genetics (3)
BioS 102 Genetics Laboratory (1)
BioS 324 Bacteriology (3)
BioS 325 Bacteriology Laboratory (1)
BioS 345 Molecular Genetics (3)
BioS 346 Molecular Genetics Laboratory (1)
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 (10-12)

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 Biology Laboratory (1)
Math 21, 22 Calculus I and II (8)
Chm 21, 22 Introductory Chemical Principles and Laboratory (5)

sophomore year
BioS 101 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 Laboratory (5)
Phy 13, 14 Introductory Physics II and Laboratory (4 or 5)
(or 21, 22)

junior year
BioS 324 Bacteriology (3)
BioS 325 Bacteriology Laboratory (1)
BioS 345 Molecular Genetics (3)
BioS 346 Molecular Genetics Laboratory (1)
Chm 31 Chemical Equilibria in Aqueous Systems (3)
BioS (Chm) 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 (1), and a minimum of 4 additional credits of BioS coursework above the 100 level. Collateral coursework must include Math 41 or 21 (3 or 4 credit hours), Chm 21 (4) and Chm 22 (1).

Departmental Honors
A student may apply for admission to the departmental honors program through a potential thesis advisor. Detailed requirements for the program may be obtained from the advisor or from the department office.

Undergraduate Courses in Biological Sciences

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)

2. Animal Survival and Adaptation (3)summer
Introductory course in evolutionary biology for non-science majors. Why species appear, change, become successful, divide into several species, and eventually become extinct. Lecture and laboratory experience. (NS)

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)

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)

32. Introduction to Cell/Molecular Biology Laboratory (1)

51. Introduction to the Vertebrates (4)
Evolution, systematics, distribution, behavior and ecology of the major classes of vertebrates, with emphasis on the North American vertebrate fauna. Two lectures, one tutorial, and one lab or field trip. (NS)

101. Genetics (3)
The structure, function, and continuity of hereditary information. Major topics include mechanisms and regulation of gene expression, replication and transmission of genetic material, mutation, and organization and change of genetic material in populations. Prerequisites: BioS 31. (NS)
9 Descriptions of Courses

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.

110. (Psyc 110) Experimental Design and Statistical Analysis (3)
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)

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 habit 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)

151. Vertebrate Field Biology (3)
Field studies on the diversity and distribution of local vertebrates. Emphasis on methods of sampling, collecting and identifying populations and on measurement of the physical environment. Two lectures per week, laboratories on Friday afternoon and on Saturday during the first seven weeks. Prerequisite: Consent of department. (NS)

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: BioS 51 or BioS 177, or consent of instructor. (NS)

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: Psyc 1 or BioS 51 or EES 31 or BioS 31. (NS)

202. BiomedicalExternship (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 chairperson required. (NS)

221. Human Histology (3)
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)

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 chairperson. (ND)

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)

251. Writing and Molecular Biology (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: BioS 101. (NS)

261. Special Topics in Molecular Biology (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 chairperson. (NS)

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 chairperson. (NS)
For Advanced Undergraduates and Graduate Students

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)

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)

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)

324. Bacteriology (3)
The structure, physiology, growth, genetics and taxonomy of prokaryotes. Prerequisites: Chm 51 and BioS 101. Corequisite: BioS 325. (NS)

325. Bacteriology Laboratory (1)
Standard procedures and metabolic tests used in determinative bacteriology; aseptic technique, sterilization, enumeration, and control of bacterial growth; other selected topics. Corequisite: BioS 324. (NS)

329. Herpetology (3)
Biology of amphibians and reptiles. Two lectures, one laboratory or field trip per week. Prerequisite: Consent of department. (ND)

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: BioS 51 or EES 31 or BioS 101. (NS)

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. (NS)

337. (Psych 337) Behavioral Ecology (3)
Social systems of vertebrate and invertebrate groups. Emphasis on ecological and evolutionary factors that influence social behavior. Prerequisites: BioS 51 or EES 31 or BioS 101. (NS)

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)

346. Molecular Genetics Laboratory (1)
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. (NS)

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 chairperson. (NS)

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)

356. Human Genetics and Reproduction (3)

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)

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)

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)

371. (Chm 371) Elements of Biochemistry I (3) fall
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. Prerequisite: one year of organic chemistry. (NS)
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)

373. (Psyc 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: Psyc 65 or 176 or 177. (SS)

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)

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)

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.

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)

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)

383. Molecular Biology Seminar (1)
Analysis of weekly colloquia in molecular biology. For senior biology and molecular biology majors. May be taken twice for credit. (ND)

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)

388. Biological Sciences Honors Seminar (1)
Continuation and extension of BioS 387. Departmental permission required. (ND)

391. Undergraduate Research (1-3)
Laboratory research under tutorial with a faculty member. May be taken more than once for credit. Prerequisites: junior standing; BioS 101, 102, 225; and a cumulative average of 3.0 in the major, or consent of instructor. (ND)

393. Independent Research (1-3)
Individual research projects designed and executed in collaboration with a faculty sponsor. May be repeated once for credit. Prerequisite: BioS 134 or BioS 277 or Psyc 210, or consent of instructor. (ND)

395. 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)

396. Thesis (3) spring
Execution of project designed in BioS 395. Final report and oral presentation. Prerequisite: BioS 395 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: Molecular Biology (Ph.D. in molecular biology), Behavioral and Evolutionary Biology (Ph.D. in either behavioral neuroscience or behavioral and evolutionary bioscience), and Biochemistry (Ph.D. in biochemistry). The graduate school requires students to register for 72 postbaccalaureate credits to earn the Ph.D. The types of registered credits may include core courses, electives, research, dissertation, special study, or seminar credits.

In the Division of Molecular Biology, research areas include microbial evolution and genetics, plant and animal molecular genetics, developmental genetics, eukaryotic cell biology, regulation of gene expression, and virology. Each student is initially guided by his or her own faculty committee. A separate Ph.D. committee later directs progress toward the advanced degree and tailors the program
to fit special needs and interests of the student. Ph.D. requirements include three formal examinations, the qualifying exam, the general exam, and the dissertation defense.

In the Division of Behavioral and Evolutionary Bioscience (BEB), research areas include behavioral neuroendocrinology in rodents, ecology and animal behavior in a variety of animals including coral reef fishes, and functional morphology in reptiles. 30 credit hours of course work, including 24 hours of 300-400 level courses from at least 3 different professors teaching courses in this area are required for the master's degree. For the Ph.D., three additional advanced 400 level seminar courses appropriate to the student’s level of specialization are required beyond the master’s requirements. Students are required to pass a general examination after completing the master’s and upon entering the Ph.D. program. There are three research requirements each of which includes a written and oral presentation to the faculty in this area: First-year research project, master's thesis, and a doctoral dissertation.

In the Division of Biochemistry, research areas include DNA structure and function, and regulation of protein synthesis. 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 (Students with one year of undergraduate biochemistry can fulfill this requirement by passing a proficiency test at the time of matriculation), BioS 469, 470, Chm 423, BioS 345, and a seminar course. BioS 408 or Chm 400 must also be completed before beginning research. Additional courses (from biochemistry, molecular biology and bio-organic chemistry) will be chosen with the help of the advisor to reach a minimum of 24 course credits (at least 12 of which must be at the 400 level). Research is the other major component of the graduate degree program (6 credits minimum are required at the MS level). Research is continued until the completion of work needed for the dissertation. Degree requirements include a two part general exam and the dissertation defense.

Graduate study leading to the M.S. and Ph.D. degree in biology is also available. Course requirements for the Ph.D. degree are determined on an individual basis by the student and the dissertation committee. The centerpiece of the doctoral program is a concentrated research effort that culminates in a significant contribution to the field of biology. Sometime prior to seven months before finishing the dissertation, the student must pass a general examination administered by the dissertation committee. The defense of the dissertation serves as the final examination for the doctorate. It is expected that the results of the dissertation research will be published in primary journals.

Graduate Courses in the Biological Sciences

404. (Psyc 404) Behavioral Neuroscience (3)
Theoretical and empirical issues in biopsychology. Prerequisite: Graduate standing or consent of instructor.

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.

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.

407. Research in Biological Science (1-9)
Laboratory investigations in one of the department’s research areas.

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.

409. Advanced Morphology (3)
A laboratory course in special phases of morphology, such as comparative osteology, comparative morphology or embryology of the vertebrates, etc., to meet the individual interests of the student.

410. Special Topics in Behavioral and Evolutionary Bioscience (1-3)
Readings and discussions on selected topics not covered in the general graduate offerings. May be taken more than once for credit.

411. Advanced Cell Biology (3)
Cell structure and biochemistry, as related to specialized cell functions.

412. (Psyc 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.

414. (Psyc 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.

415. (Psyc 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.

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 chairperson.

419. Bacterial Genetics (3)
Structure and function of genetic information in procaryotes. Composition, size, and organization of chromosomes and accessory elements; mechanisms of replication, recombination, transmission, and mutation; variation within and among strains.

420. (Psyc 420) Pheromonal Communication (3)
Mechanisms of pheromone synthesis, biochemistry, sensory transductions, neuroanatomy/neuroendocrinology, and adaptive significance. Prerequisite: BioS 404 and consent of instructor.

421. Molecular Cell Biology I (3)
Molecular aspects of cell structure, cell motility, intracellular transport; and biomembrane dynamics. Prerequisite: BioS 411 or equivalent.

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.

425. Male Reproductive Biology (2 or 3)
Molecular, cellular, and genetic aspects of the mammalian male reproductive system. Prerequisite: BioS 367 or equivalent.

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 preparation; immunological detection methods; molecular cloning techniques; oocyte microinjection techniques; tissue culture methods; and autoradiography.

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.

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.

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.

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.

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 chairperson.

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. Not open to students who have taken BioS 337.

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.

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.

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.
466. Structure and Function of RNAs 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.

467. (Chm 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.

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. Prerequisite: one year of biochemistry and one year of physical chemistry or permission of the department chair.

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.

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.

471. (Chm 471) Eucaryotic Biochemistry (3) alternate years
Biochemistry of selected eucaryotic processes including hormone chemistry, blood clotting, immunochernistry, 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 chairperson.

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 chairperson.

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.

477. (Chm 477) Topics in Biochemistry (1-3) alternate years
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 chairperson.

479. (Chm 479) Biochemical Techniques (3) alternate years
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.

480. (Chm 480) Advanced Biochemical Preparations (1-3) alternate years
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 chairperson.

483. (Psych 483) Special Topics in Behavioral Neuroscience (3) alternate years
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.

488. Seminar in Neuroscience, Behavior, and Evolution (1) alternate years
An advanced seminar in current research developments. May be taken more than once for credit.
Chemical Engineering

Professors. Dennis W. Hess, Ph.D. (Lehigh), chairperson and T.L. Diamond Professor; Fred P. Stein, Ph.D. (Michigan), associate chairperson; 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; Mohamed S. El-Aasser, Ph.D. (McGill); Christos Georgakis, Ph.D. (Minnesota); James T. Hsu, Ph.D. (Northwestern); Andrew Klein, Ph.D. (North Carolina State); William L. Luyben, Ph.D. (Delaware); Janice A. Phillips, Ph.D. (Pennsylvania); William E. Schiesser, Ph.D. (Princeton), McCann Professor; Leslie H. Sperling, Ph.D. (Duke); Cesar A. Silebi, Ph.D. (Lehigh); Harvey G. Stenger, Jr., Sc.D. (M.I.T.), dean of college of engineering and applied science; Israel E. Wachs, Ph.D. (Stanford).

Associate professor. Manoj K. Chaudhury, Ph.D. (SUNY-Buffalo), Dow Corning associate professor.

Assistant professor. Maria M. Santore, Ph.D. (Princeton).

Adjunct professor. William R. Hencke, M.S.E. in ChE (Michigan); Paul M. Mathias, Ph.D. (Florida); Robert G. Sander, B.S. (Lehigh).

Research engineers. E. David Sudol, Ph.D. (Lehigh); Kemal Tuzla, Ph.D. (Technical University of Istanbul).


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 contains offices 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 IMBT 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.

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 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.

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 affords 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. Students register for OSI through ChE 185 and 186.

Chemical Engineering offers specialization certificates in polymer science, biotechnology, and process modeling and control.

Requirements of the Major

freshman year: see Recommended Freshman Year, page 45.

sophomore year, first semester (18 credit hours)
ChE 31 Material and Energy Balances of Chemical Processes (3)
Chm 31 Chemical Equilibria in Aqueous Systems (3)
Phy 21 Introductory Physics II (4)
Phy 22 Introductory Physics Laboratory II (1)
Math 23 Analytic Geometry and Calculus III (4) elective (3)

sophomore year, second semester (18 credit hours)
ChE 44 Fluid Mechanics (4)
ChE 210 Chemical Engineering Thermodynamics (4)
ChE 179 Professional Development (1)
Chm 187 Physical Chemistry I (3)
Math 205 Linear Methods (3) elective (3)

junior year, first semester (18 credit hours)
ChE 151 Introduction to Heat Transfer (3)
ChE 201 Methods of Analysis in Chemical Engineering (3)
Chm 51 Organic Chemistry I (3)
Chm 53 Organic Chemistry Laboratory I (1)
Chm 192 Physical Chemistry Laboratory (2) electives (6)

junior year, second semester (18 credit hours)
ChE 242 Introduction to Process Control and Simulation (3)
ChE 244 Mass Transfer and Separation Processes (3)
ChE 211 Chemical Reactor Design (3)
Chm 52 Organic Chemistry II (3) electives (6)

senior year, first semester (17 credit hours)
Chm 189 Physical Chemistry II (3)
ChE 202 Chemical Engineering Laboratory I (2)
ChE 233 Process/Plant Design (3) electives (9)

senior year, second semester (15 credit hours)
ChE 203 Chemical Engineering Laboratory II (2)
ECE 81 Principles of Electrical Engineering (4) electives (9)

The total number of credits required for graduation is 135. A total of 39 credits in electives must be taken. These electives are of six types:
(a) Humanities/Social Sciences: A total of 18 credits of electives in humanities and social science which must include either Eco 11 or Eco 12. (Note that these electives are in addition to the 6 hours of required freshman English). See description of HSS requirement on page 45.
(b) Approved courses in other engineering departments (CE, EECS, IE, MEM, MAT): A total of 6 credit hours is required. Of these at least 1 credit hour must be in engineering design.
(c) Chemistry: 3 credit hours of 200-level or higher.
(d) Science: 3 credit hours in an approved science course in the departments of chemistry, physics, mathematics, molecular biology, or earth and environmental sciences.
(e) Chemical Engineering: A total of 3 credit hours is required. At least 1 credit hour must be of engineering design.
(f) Free electives: 6 credit hours in any subject area (including advanced chemical engineering) are required.

Undergraduate Courses

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)

44. Fluid Mechanics (4) spring

60. Unit Operations Survey (3) fall
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)

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)

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)

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)

186. Undergraduate Research II (3)
A continuation of the project begun under ChE 185. Prerequisite: ChE 185 or consent of the department chairperson. (ES 2), (ED 1)

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)

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)

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)

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. Prerequisite: Math 205. (ES 2), (ED 1)

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)

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)

233. Process/Plant Design (3) fall
Economic principles involved in the selection of process alternates and determination of process operation costs. Preliminary design of chemical plants including optimization of process configuration, market limitations on plant planning, environmental and regulatory restrictions. Prerequisite: ChE 151 and ChE 210. (ES 0), (ED 3)

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. Prerequisite: ChE 201, ChE 151, and Engr 1. (ES 1), (ED 2)

244. Mass Transfer and Separation Processes (3) spring
Diffusion, fluxes, and component conservation equations. Fick's law. Unsteady state diffusion. Convective mass transfer. Interphase mass transport coefficients. Design of multicomponent distillation, absorption, extraction, and fixed bed processes. Prerequisite: ChE 31 and ChE 44. (ES 1), (ED 2)
For Advanced Undergraduates and Graduate Students

301. Process Design (3) fall
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 nonlinear systems. Effects of uncertainty in process design. (ES 0), (ED 3)

312. (Chem 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: Met 210, Chm 187, or equivalent. (ES 3), (ED 0)

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, foaming, freezing, and hydrate formation. Prerequisite: ChE 211. (ES 2), (ED 1)

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 Sciences. (ES 1), (ED 2)

331. Separation Processes (3) spring, 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)

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 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 chairperson. (ES 4), (ED 0)

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)

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)

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)

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.

360. (ME 360) Nuclear Reactor Engineering (3)
A consideration of the engineering problems in nuclear reactor design and operation. Topics include reactor fuels and materials, thermal aspects, instrumentation and control problems, radiation protection and shielding, fuel processing, and reactor design. Prerequisite: senior standing in the College of Engineering and Applied Sciences. (ES 1.5), (ED 1.5)

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)
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)

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 industries. Specific projects are normally guided by faculty from several departments with consultants from off the campus. The course may be repeated for credit. (ED all)

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)

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 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 1.5), (ED 1.5)

388. (Chem 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., Chem, or Mat, or permission of the instructor. (ES 2), (ED 1)

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)

392. (Chem 392) 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)

393. (Chem 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 amorphous states (including viscoelastic and mechanical properties). Structure, morphology, and behavior. Prerequisite: senior level standing in Chem, or Mat, or permission of the instructor. (ES 1.5), (ED 1.5)

394. (Chem 394) Organic Polymer Science (3) spring
Organic chemistry of synthetic high polymers. Functionality and reactivity of monomers and polymers. Theory of stepgrowth and condensation polymerization in homogeneous and heterogeneous media. Polymerization by addition, elimination, substitution and coupling reactions. Ionic free-radical and coordinate catalysis. Prerequisite: one year of physical chemistry and one year of organic chemistry. (ES 3), (ED 0)

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 ensure 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 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, Zettlemoyer Center for Surface Studies, and BioProcessing Institute.

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: emulsion polymerization and latex technology; bulk polymer systems; process control; process improvement studies; rheology; computer applications; environmental engineering; thermodynamics; kinetics and catalysis; enzyme technology; and biochemical engineering.

Career Opportunities
Master of science 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 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 386 and 486-based PCs and RS/6000 workstations, connected by a University-wide high speed network. The central computers in this Unix distributed computing environment include several RS/6000 Model 990 workstations for compute-intensive applications and worldwide networking via Internet/WWW. The distributed computing network is expanded as the demand for computing resources and services grows thereby ensuring the Chemical Engineering Department 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 that fact at the time they apply for admission.

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 of kinetics of emulsion polymerization and copolymerization, colloidal surface and interfacial aspects of emulsion polymers, and the process 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.

Master of engineering degree. Students may earn the master of engineering degree in chemical engineering upon completion of a course of study and an engineering project meeting all the requirements of the master of science degree. The master of engineering student, however, elects courses closer to engineering practice, and carries out a project of more practical engineering flavor than that of the M.S. candidate. In some cases the project of the master of engineering student will be done in close collaboration with local industry, as noted above.

Major Requirements
The requirements for the master of science degree are listed in the section on The Graduate School. All candidates in residence for the M.S. degree are required to complete a master of science research report 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.

The requirements for the doctor of philosophy degree also are listed in the section on The Graduate School. 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

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

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

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.

413. Heterogeneous Catalysis and Surface Characterization (3) fall
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, hydrotreating, and cracking. Wachs

415. Transport Processes (4) 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, Schiesser


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

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

430. Mass Transfer (3) 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

433. (ECE 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: M.E. 343 or E.C.E. 212 or Ch.E. 386 or consent of instructor. Johnson, Georgakis

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) feedforward 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 M.E. 433 or E.C.E. 433 or consent of instructor. Georgakis

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, quasi-linearization and invariant-imbedding techniques for nonlinear system parameter identification included. Prerequisite: Ch.E. 433 or M.E. 433 or E.C.E. 433 or consent of instructor. Johnson

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 M.E. 433 or E.C.E. 433 or consent of instructor.

438. Process Modeling and Control Seminar (1)
Presentations and discussions on current methods, approaches, and applications. Credit cannot be used for the M.S. degree.

444. Bioseparations (3) fall, every other year
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.

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.

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.

448. Topics in Biochemical Engineering (3)
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.

450. Special Topics (1-12)
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.

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.

455. Seminar (1-3)
Critical discussion of recent advances in chemical engineering. Credit above one hour is granted only when different material is covered.

460. Chemical Engineering Project (1-6)
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.

461. Mathematical Methods in Chemical 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

464. Numerical Methods in Engineering (3)
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

480. Research (3)
Investigation of a problem in chemical engineering.

481. Research (3)
Continuation of ChE 480.

482. (Chm 482, Mat 482) Engineering Behavior of Polymers (3)
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,
special emphasis on thermodynamics, kinetics, and adsorbed polymer chains. Diffusion and adhesion at polymer-chains. A brief survey of the rheological properties of polymer flow processes. Application of fundamental principles of mechanics, fluid dynamics, and heat transfer to the analysis of a wide variety of polymer adhesion, and the effects of fillers, plasticizers, moisture and aging on mechanical behavior.

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 include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of polymer surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation and various application problems. El-Aasser, Vanderhoff, Klein

484. (Chm 484) Crystalline Polymers (3)
An in-depth treatment of the morphology and behavior of both polymer single crystals and bulk crystallized systems. Emphasis is placed on the relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. A detailed discussion of the 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.

485. (Chm 485, MAT 485) Polymers Blends and Composites (3)
An intensive study of the 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

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

487. Polymer Interfaces (3) spring
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.

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. Kamil Klier, Ph.D. (Czechoslovak Academy of Science, Prague), university professor and chairperson; Jack A. Alhadeff, Ph.D. (Oregon Medical School); Ned D. Heindel, Ph.D. (Delaware), Howard S. Bunn Professor of Chemistry; Charles S. Kraihanzel, Ph.D. (Wisconsin); John W. Larsen, Ph.D. (Purdue); Steven L. Regen, Ph.D. (M.I.T.); Keith J. Schray, Ph.D. (Penn State), assistant chairperson; Gary W. Simmons, Ph.D. (Virginia); John W. Vanderhoff, Ph.D. (Buffalo), co-director, Emulsion Polymers Institute; Daniel Zeroka, Ph.D. (Pennsylvania).

Associate professors. Natalie Foster, Ph.D. (Lehigh); Leonard E. Klenzoff, Ph.D. (California-Berkeley); James E. Roberts, Ph.D. (Northwestern).

Assistant professors. John W. Benbow, Ph.D., (Indiana); Gregory S. Ferguson, Ph.D. (Cornell); Michael Freund, Ph.D. (University of Florida); Kenneth Haug, Ph.D. (Minnesota).

Adjunct professors. William R. Anderson (San Jose State); Thomas Hamilton (Wales); Tibor Sipos, Ph.D. (Lehigh); Francis J. Waller, Ph.D. (Vermont).

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. From soft contact lenses and synthetic blood to longer-lasting paint and alternative fuel sources, the study of chemistry has provided the solutions to complex problems and has improved the quality of all phases of human life. A particular strength of this department is in Surface and Interface Chemistry that bridges many areas of modern science and technology.

That chemists at all levels of education find a market for their skills and knowledge in every employment area is further demonstration of the breadth of the science of chemistry. Chemists provide the technical backbone for the manufacturing industries (pharmaceuticals, plastics, paper, electronics, agriculture), for service industries (clinical and forensic laboratories, academe, environmental protection, information science) and for governmental positions in regulatory agencies and in science policy analysis. Many chemists are also employed in non-traditional areas: O patent law, insurance underwriting, sales, product management, journalism, and even banking.

The alluring challenge of chemistry inspires many bachelor degree holders to study for an advanced degree so that undergraduate preparation in chemistry enables future study within the discipline of chemistry and in other areas as well. Chemistry or biochemistry is the strongest preparation for graduate studies or professional school in the health-related
disciplines (medicine, pharmacology, biochemistry) as well as for other science programs (materials science, polymers, environmental studies, 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, geological sciences, material science, molecular biology, physics, and chemical engineering, so that students can normally transfer with no loss of credits at least 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, 392, 393, 394, 395, 396.

**Environmental Chemistry**
- Suggested earth and environmental sciences 31, 32, 351.
- Suggested chemical engineering electives: 320, 321.
- Suggested chemistry electives: 303, 395.
- Suggested civil engineering elective: 374.

**Geology**
- Suggested chemistry electives: 303, 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: 211, 312.

Certain of the above courses can be used to waive required graduate courses for the M.B.A. at Lehigh.

**The Five-Year Program**
Five year programs are available for students to receive bachelors of science or bachelors of arts degrees and the masters of science degree in chemistry with a concentration in one of several fields of chemistry (inorganic, organic, analytical, physical, polymers, biochemistry, or materials chemistry, the latter has financial aid available.)

**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 Sciences. 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 they have been admitted. The B.A. program in the College of Arts and Science 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, geochmistry 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 Foreign Language 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.

**Bachelor of Science Degree in Chemistry - College of Engineering and Applied Science**

**Freshman Year (see page 45) (30-31 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 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)

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</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>Phy 21</td>
<td>Introductory Physics II (4)</td>
</tr>
<tr>
<td>Phy 22</td>
<td>Introductory Physics Laboratory II (1)</td>
</tr>
<tr>
<td>Math 23</td>
<td>Analytic Geometry and Calculus III (4)</td>
</tr>
</tbody>
</table>

**Modern Foreign Language requirement** (3)* (See details above)

*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.

**Sophomore Year, Second Semester** (16 credit hours)

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</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>Phy 21</td>
<td>Introductory Physics II (4)</td>
</tr>
<tr>
<td>Phy 22</td>
<td>Introductory Physics Laboratory II (1)</td>
</tr>
<tr>
<td>Math 23</td>
<td>Analytic Geometry and Calculus III (4)</td>
</tr>
<tr>
<td></td>
<td>modern foreign language</td>
</tr>
<tr>
<td></td>
<td>requirement</td>
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<tr>
<td></td>
<td>(3)* (See details above)</td>
</tr>
</tbody>
</table>
Descriptions of Courses

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 (3) (See details above)
Humanities/Social Science requirement (3)

junior year, first semester (15 credit hours)
Chm 192  Physical Chemistry Laboratory (2)
Chm 234  Analytical Chemistry Laboratory (1)
Chm 332  Analytical Chemistry (3)
Chm 341  Chemical Physics and Bonding (4)
Chm 205  Main Group Elements (2)
Eco 11 or 12  Economics (3)

junior year, second semester (17 credit hours)
Chm 353  Organic Analysis Laboratory (3)
Chm 307  Advanced Inorganic Chem. (3)
Chm 201  Technical Writing (2)

Humanities/Social Science requirement (3)
free electives (6)

senior year, first semester (15 credit hours)
advanced chemistry elective (3)
Humanities/Social Science requirement (3)
free electives (9)

senior year, second semester (14 credit hours)
Chm 338  Advanced Chem. Analysis (2)
advanced chemistry elective (3)*
free electives (9)

*This becomes a free elective if the advanced chemistry elective requirement was taken in the fall 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 ResearchLab
Chm 381 Radiation and Structure
Chm 382 Spectroscopy and Photochemical Kinetics
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.

Summary
Total required chemistry hours  44
Total required physics, mathematics, computer hours  28

Total required college distribution hours  24*
Unrestricted elective hours  27
Program total hour requirement is 123

*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 foreign language requirement.

Bachelor of Science Degree in Chemistry  College of Arts and Sciences

I. College and University Requirements  28 hours
a.  English 1, 2  6 hours
b.  Arts and Sciences I  1 hour
c.  College Seminar 3 hours
d.  Non-science electives  18 hours to be broadly distributed in fields of thought other than natural science and mathematics, including at least 9 hours each in humanities and social sciences.

II. Collateral Science Requirements  28 hours
a.  Physics 11, 12, 21, 22  10 hours
b.  Mathematics 21, 22, 23, 205  15 hours
c.  Computer Science 11 or Engineering 1  3 hours

III. Required Chemistry Courses  44 hours
a.  Introductory Chemistry  Chemistry 75, 76  8 hours [The Chemistry 21, 22, 31 sequence may be substituted.]
b.  Organic Chemistry  Chemistry 51, 52, 53, 58, 353  11 hours
c.  Inorganic Chemistry  Chemistry 205, 307  5 hours
d.  Physical Chemistry  Chemistry 187, 192, 341  9 hours
e.  Analytical Chemistry  Chemistry 234, 332, 338  6 hours
f.  Technical Writing  Chemistry 201  2 hours (W-1 course)
g.  Advanced Chemistry Elective  3 hours

[See list of choices for this Advanced Chemistry Elective requirement under the B.S. chemistry program, Engineering College.]

IV. Free Electives  21 hours (based on 121 total hours)
**Model Pattern Roster**

**freshman year, first semester** (15 credit hours)
- Arts 1: Choices and Decisions (1)
- Engl 1: 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 credit hours)
- 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 credit hours)
- 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)
- CSc 11 or Engr I: Computer Programming (3)

**sophomore year, second semester** (16 credit hours)
- Chm 52: Organic Chemistry II (3)
- Chm 58: Organic Chemistry Lab II (1)
- Chm 187: Physical Chem. I (3)
- Math 205: Linear Methods (3)
  - distribution requirement (3) and free electives (6)

**junior year, first semester** (15-16 credit hours)
- Chm 192: Physical Chemistry Lab (2)
- Chm 234: Analytical Chemistry Lab (1)
- Chm 332: Analytical Chemistry (3)
- Chm 341: Chem. Physics and Bonding (4)
- Chm 205: Main Group Elements (2)
  - modern foreign language requirement (3-4)

**junior year, second semester** (14-15 credit hours)
- Chm 353: Organic Analysis Laboratory (3)
- Chm 307: Advanced Inorganic Chem. (3)
- Chm 201: Technical Writing (2)
  - modern foreign language requirement (3-4)
  - distribution requirement free elective (3)

**senior year, first semester** (15 credit hours)
- advanced chemistry elective (3)
  - distribution requirements free electives (12)

**senior year, second semester** (14 credit hours)
- Chm 338: Advanced Chem. Analysis (2)
  - advanced chemistry elective (3)*
  - distribution requirements free electives (9)

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*This becomes a free elective if the advanced chemistry elective was taken in the fall semester of the senior year.

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**Bachelor of Arts Degree in Chemistry**

**College of Arts and Sciences**

I. College and University Requirements
- 10 hours
  - a. English 1, 2 6 hours
  - b. Arts and Sciences 1 1 hour
  - c. College Seminar 3 hours

II. Distribution Requirements (other than above) 18 hours minimum
- a. Social Sciences 9 hours
- b. Humanities 9 hours

III. Collateral Science Requirements 28 hours
- a. Physics 11, 12, 21, 22 10 hours
- b. Mathematics 21, 22, 23, 205 15 hours
- c. Computer Science 11 or Engineering 3 hours

IV. Required Chemistry Courses 33 hours
- a. Introductory Chemistry 8 hours. [The Chemistry 21, 22, 31 sequence may be substituted.]
- b. Organic Chemistry 8 hours
- c. Inorganic Chemistry 205 2 hours
- d. Physical Chemistry 9 hours
- e. Analytical Chemistry 234, 332 4 hours
- f. Technical Writing 201 2 hours

V. Free Electives 32 hours maximum (based on 121 total hours)
Model Pattern Roster

freshman year, first semester (15 credit hours)

Arts 1   Choices and Decisions (1)
Engl 1   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 credit hours)

Engl 2   Composition and literature (fiction, poetry, drama) (3)
Phy 11, 12 Introductory Physics I and Laboratory (5)
Chm 76   Concepts, Models, and Experiments II (4)
Math 22  Calculus II (4)

sophomore year, first semester (16-17 credit hours)

Chm 51   Organic Chemistry I (3)
Chm 53   Organic Chemistry Lab I (1)
Phy 21   Introductory Phys. II (4)
Phy 22   Introductory Phys. Lab II (1)
Math 23  Calculus III (4)
Csc 11 or Engr 1 Computer Programming (3)

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)
        distribution requirements (3) and free electives (6)

junior year, first semester (15-16 credit hours)

Chm 192  Physical Chemistry Lab (2)
Chm 234  Analytical Chemistry Lab (1)
Chm 332  Analytical Chemistry (3)
Chm 341  Chem. Physics and Bonding (4)
Chm 205  Main Group Elements (2)
        modern foreign language requirement (3-4)

junior year, second semester (14-15 credit hours)

Chm 201  Technical Writing (2) (W-I course)
        modern foreign language requirement (3-4)
        distribution requirements and free electives (9)

senior year, first semester (15 credit hours)

distribution requirements and free electives (15)

senior year, second semester (15 credit hours)

distribution requirements and free electives (15)

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

Necessary pre- or co-requisites for the above would be Chm 21 and 22, Math 21 and Physics 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 chairman.

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. Please see the section on Biochemistry on page 119 for details on each major.

Undergraduate Courses in Chemistry

5. Chemistry and National Issues

For majors other than science and engineering. Chemistry and current controversies. The atmosphere; global warming, ozone depletion, pollution; water; pollution and treatment; energy; generation and side effects; health; chemicals of life, drugs, carcinogens, personal care; materials; natural and synthetic; food; production and preservation; chemistry; benefits and liabilities. Chm 22 may be taken concurrently for laboratory credit. (NS)

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. Prerequisite: Math 21, 31 or 41 previously or concurrently. Three lectures, one recitation. (NS)

22. Chemical Principles Laboratory (1) fall-spring
A laboratory course to be taken concurrently with Chm 21. One three-hour laboratory period per week.

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 solutions.
media. Prerequisite: Chm 21, Math 21. Two lectures and one three-hour laboratory period. (NS)

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)

52. Organic Chemistry II (3)spring
Continuation of Chm 51. Prerequisite: Chm 51.

53. Organic Chemistry Laboratory I (1)fall
Preparation of pure organic compounds. Modern techniques of characterization. Prerequisite: Chm 51 previously or concurrently. (NS)

58. Organic Chemistry Laboratory II (1)spring
Continuation of Organic Chemistry Laboratory I. Prerequisite: Chm 53 previously; Chm 52 previously or concurrently.

75. Concepts, Models and Experiments I (4)fall
A first-semester course in chemistry for students planning to major in chemistry or a chemistry-related field. Chemical and physical properties, structures, bonding concepts, and analysis of inorganic substances. Laboratory includes synthesis, separation and analysis procedures; computer applications to chemistry. Three lectures, one laboratory. (NS)

76. Concepts, Models and Experiments I (4)spring
Continuation of Chemistry 75. Three lectures, one laboratory. Prerequisite: Chm 75 or departmental consent. (NS)

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 or 41 previously or concurrently. (NS)

189. Physical Chemistry II (3)fall

192. Physical Chemistry Laboratory (2)
Laboratory studies that illustrate the various fields of study in experimental physical chemistry. Prerequisite: Chm 187.

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)

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 chairperson. (ND)

205. Main Group Elements (2)fall
Chemistry of the main group elements. Prerequisite: Chm 31 or 76. (ND)

209. Chemistry of Organic and Inorganic Materials (3)fall
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 developed. Reactions involving alkenes (especially vinyls), hydroxyl, amine, oxirane, and halogen groups will be emphasized. Crystal structures and physical properties. Prerequisite: Chm. 21 or 75. Sperling. (ND)

234. Analytical Chemistry Laboratory (1)fall
Laboratory course: experiments coordinated with and illustrating methods and principles discussed in Chm 332.

250. Special Topics (1-3)
Selected topics in chemistry. May be repeated for credit when different topics are offered. (ND)

303. Nuclear and Radiochemistry (3)
A broad survey of nuclear science with particular emphasis on aspects of importance to chemistry and biology. Elementary nuclear theory, production, separation, and identification of radioactive and stable isotopes; use of isotopes in the study of chemical and biological systems; radiological safety; nuclear engineering. Two lectures and one lecture-laboratory. Prerequisite: Chm 187 or Chm 194, or consent of the department chairperson. (NS)

307. Advanced Inorganic Chemistry (3)spring
Introduction to transition metal complexes; theories of bonding; kinetics and mechanisms of transition metal complex reactions; selected aspects of organometallic chemistry; bioinorganic chemistry. Prerequisite: Chm 341. (NS)

312. (CHE 312, MAT 312) Fundamentals of Corrosion (3)fall
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 or Chm 187. (NS)

332. Analytical Chemistry (3) fall 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. Prerequisites: Chm 31 and 51. (NS)

336. Clinical Chemistry (3) spring Applications of analytical chemistry to clinical problems. Discussion of methods in common use and the biochemical-medical significance of the results. Prerequisites: Chm 332 and 52. Schray. (NS)

337. (EES 337, MAT 333) X-ray Diffraction of Materials (3) fall 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. Prerequisite: Mat 203 or EES 133 or senior standing in chemistry. Lyman, Chan. (NS)

338. Inorganic Analysis Laboratory (2) spring Studies of inorganic and transition metal organometallic compounds. Synthesis, characterization, and analysis by contemporary instrumental methods. Prerequisites: Chm 234, 307, 332.


350. Special Topics (1-3) Selected advanced topics in chemistry. May be repeated for credit when different topics are offered. (ND)

353. Organic Analysis Laboratory (3) spring 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 spectrometric examinations. Separation techniques for mixtures. Prerequisites: Chm 52 and 58.

358. Advanced Organic Chemistry (3) fall Reaction mechanism types and supporting physical-chemical data. Classes of mechanisms include elimination, substitution, rearrangement, oxidation-reduction, enolate alkylations, and others. Prerequisite: one year of organic chemistry. (NS)

368. Advanced Organic Laboratory (2) The synthesis and study of organic compounds illustrating the important techniques and special pieces of apparatus commonly used in organic chemical research. Prerequisite: one year of organic chemistry and laboratory.

371. (BIOS 371) Elements of Biochemistry I (3) fall 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. Prerequisite: one year of organic chemistry. (NS)

372. (BIOS 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)

375. Research Chemistry Laboratory (1-3) fall-spring An introduction to independent study or laboratory investigation under faculty guidance. Prerequisite: consent of department chairperson.

376. Advanced Research Chemistry Laboratory (1-6) fall-spring Advanced independent study or laboratory investigation under faculty guidance. Prerequisite: 3 credits of Chm 375. May be repeated for credit.

377. (BIOS 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: Chm 371, previously or concurrently.

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.

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)

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)

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. Vanderhoff. (NS)

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. Prerequisite: Chm 187, 189 or 341 and 51. El-Aasser

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)

393. (CHE 393, MAT 343) 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)

394. (CHE 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. Prerequisite: one year of physical chemistry and one year of organic chemistry. Vanderhoff. (NS)

395. 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 341 or equivalent. Chaudhury. (NS)

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, biochemistry, 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.

Admission to graduate study in chemistry assumes that a student has met, or is willing to meet through further study, minimum undergraduate requirements for a bachelor’s degree in chemistry. This would include (beyond two semesters of introductory chemistry) two semesters of organic chemistry, two semesters of physical chemistry, two semesters of analytical chemistry and one semester of inorganic chemistry. A promising student whose degree is in a field related to chemistry (e.g., biology, chemical engineering) may be admitted to graduate study in chemistry provided that any deficiencies in basic chemistry preparation are made up in the first year of graduate study and noting that some of the courses required for this may not carry graduate credit.

The Chemistry Department will administer proficiency examinations in analytical, biochemistry, inorganic, organic and physical chemistry to all regular graduate students at the time of matriculation. Each student is required to take three examinations. Information regarding material to be covered on these examinations will be sent to each student several months in advance of matriculation. It is expected that each student will prepare diligently for these tests. 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 fails one or more of the proficiency examinations will meet with the department 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 1 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 is surmounted, the remaining time is spent completing (and ultimately defending) the thesis research under the guidance of the research adviser and the thesis 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 colloid chemistry. Biochemistry research is located in Iacocca Hall of the Mountaintop Campus. Physiological chemistry research is located in the Sherman Fairchild Laboratory, Whitaker Laboratory, in the Seeley G. Mudd Building. Solid-state chemical research is located in the Sherman Fairchild Laboratory, in the Seeley G. Mudd Building, and in Sinclair Laboratory. Polymer chemistry research laboratories are located in Whitaker Laboratory, Sinclair Laboratory, Iacocca Hall of 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, clinical-biomedical applications, mechanisms of electrode processes, adsorption; redox behavior of transition metal complexes; development of novel immunosassays for clinical diagnosis; atomic resolution surface analysis, electrochemical scanning tunneling microscopy, sensor array design and response pattern recognition.

Biochemistry. Characterization of lysosomal glycosidases and glycosyltransferases; functional role of carbohydrates in glycoproteins; abnormal glycoprotein metabolism in human diseases; synthesis and characterization of novel polynucleotides; sequence dependence of the B-Z transition of DNA; non-isotopic immunosassays; protein surface binding phenomena; development of \textit{in vitro} evaluation techniques for prescreening candidate pharmaceuticals; structural dynamics and molecular associations of biologically significant molecules; relaxation phenomena in NMR and the development of contrast enhancement agents for medical imaging.


Physical chemistry. Colloid and surface research include latexes, surface coatings, colloidal stability, adsorption, surface properties of catalysts relating powder flow to their surface chemistry, water at surfaces, fundamental studies of gas-solid surface reactions, printing inks, chemical reactions in small confined volumes, microcalorimetric and FTIR spectrometric studies of Lewis acid-base interactions at interfaces and surface spectroscopy. Solid-state chemistry includes studies of point defects in oxides and oxide growth. Other fields include photochemical dynamics, nuclear magnetic resonance and applications of quantum mechanics and statistical mechanics to problems of chemical interest. Role of non-covalent bonding in the macromolecular structure of coals. Stabilities of homoconjugated carbocations. Thermodynamics of formation of organic intermediates. Electrostatics of non-aqueous systems. Single crystal vibrational and electron surface spectroscopy; structure-function relationships in catalysis; intrazeolitic transition metal ion complexes-spectroscopy, structure and reactivity; kinetics of heterogeneously catalyzed reactions.

Polymer chemistry. 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 crystallization 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; mechanical properties of polymer printing plates; NMR studies of polymers in aqueous solutions and gels; ionic motion through polymer films.

Major Instrumentation

Chemistry research spans all areas: analytical, biochemistry, inorganic, organic, 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 -135°C), rotary evaporator, 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 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 gradient spectrometer for solutions. Photochemistry equipment—lamps and filters for selected wavelength work. Polarographs, chronopotentiometers, electrophoresis apparatus, electrochemical impedance, electrochemical scanning tunneling microscope, potentiostats, and rotating disk electrode. Titration equipment (automated and computer interfaced), portable data interface (6-channel 50kHz), 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, photocoustic and attenuated total reflectance capability, laser Raman, GC mass spectrometers, time-of-flight (TOF) mass spectrometer with \(^{252}\)Cf desorption source. Mössbauer spectrometer, positron 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), photocorrelation spectroscopy for submicron particle analysis. Ellipsometer, contact angle capabilities, gas adsorption apparatus (BET), temperature programmed desorption (TPD), atomic force microscope, instructional 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, the ESCA Laboratory is jointly operated with AT&T, and a network of five IBM 6000 RISC work stations is jointly operated with LCCC.

**Graduate Courses in Chemistry**

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.

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

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.

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 nitrile complexes; dioxygen and dinitrogen complexes; organic synthesis utilizing organometallic catalysts. Kraihanzel

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 chairperson. May be repeated for credit.

421. Chemistry Research (1-6)
Research in one of the following fields of chemistry: analytical, inorganic, organic, physical, polymer, biochemistry.

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

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 radioactive pharmaceuticals. Prerequisite: one year of organic chemistry. Heindel

431. Contemporary Topics in Analytical Chemistry (1)
Discussion of the current literature in analytical chemistry, including spectroscopy, separations, and electrochemistry. Students find current papers and lead discussions. May be repeated for credit.

432. Advanced Analytical Chemistry (3) alternate years
Recent developments in analysis of chemical methods. Statistical methods in analytical chemistry: treatment and interpretation of numerical data; design of experiments; application to and discussion of multistage and other methods for separating chemical species. Prerequisite: Chm 332 or equivalent.

433. Advanced Topics in Electrochemistry (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.

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.

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.

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 chairperson. Alhadeff

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.

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

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.

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 chairperson. Larsen

453. Heterocyclic Compounds (3) alternate years
An intensive study of the syntheses, reactions and properties of heteroaromatic 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.

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. Benbow

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

457. Organic Reaction Mechanisms (3) alternate years
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.

458. Topics in Organic Chemistry (3)
An intensive study of limited areas in organic chemistry. May be repeated when a different topic is offered.

466. Advanced Organic Preparations (2-3)
A laboratory course of instruction in advanced techniques of the preparation of organic compounds.

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 chairman. Behe

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 chairman. Behe

469. (BIOS 469) Biochemical Problem Solving I (1) fall
Applications of material covered in Chm 371 including techniques used in research. Prerequisite: Chm 371 previously or concurrently.

470. (BIOS 470) Biochemical Problem Solving II (1) spring
Applications of concepts covered in Chm 372 including techniques used in research. Prerequisite: Chm 372 previously or concurrently.

471. (BIOS 471) Eucaryotic Biochemistry (3) alternate years
Biochemistry of selected eucaryotic 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: Chm 372 or consent of department chairperson. Lowe-Krentz

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: Chm 372 or consent of department chairperson. Lowe-Krentz

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. Alhadef

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.

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 chairperson.

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.

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 chairperson.

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.

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 time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizer, moisture, and aging on mechanical behavior.

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. Vanderhoff, El-Aasser

484. (CHE 484, MAT 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.

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

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 395. Vanderhoff

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.

489. (CHE 489) Organic Polymer Science II (3) alternate years Continuation of Chem 394. Theory and mechanism of ionic vinyl-addition chain-growth polymerization. Chain copolymerization by radical and ionic mechanisms. 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. Vanderhoff

491. Physical Chemistry of Organic Polymer Coatings (3) alternate years Pigment/binder 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. Vanderhoff

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.

493. Organic Chemistry of Organic Polymer Coatings (3) alternate years
Film formation from solution and dispersion, and application of coatings. Mechanism and kinetics of curing glyceride oils, varnishes and alkyd resins, unsaturated polyesters, thermoplastic cellulose, acrylic and vinyl resins, epoxide resins, polyurethanes, amine- and phenol-formaldehyde resins, thermosetting vinyl and acrylic copolymers, water-based systems, natural and synthetic rubber, and silicone resins. New solventless coatings. Prerequisites: Chm 393 and 394 or equivalent. Vanderhoff

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 chairperson.

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 chairperson.

Chinese
See listings under Modern Foreign Languages.

Civil and Environmental Engineering

Professors. Le-Wu Lu, Ph.D. (Lehigh), chairman; Celal N. Kostem, Ph.D. (Arizona) associate chairman; Hsai-Yang Fang, Ph.D. (West Virginia); John W. Fisher, Ph.D. (Lehigh), director, NSF-ERC Advanced Technology for Large Structural Systems; Irwin J. Kugelman, Sc.D. (M.I.T.); Gerard P. Lennon, Ph.D. (Cornell); Arup K. Sengupta, Ph.D. (Houston); Robert M. Sorensen, Ph.D. (U.C. Berkeley); Richard N. Weisman, Ph.D. (Cornell); John L. Wilson, Ph.D. (Pittsburgh); Ben-Tseng Yen, Ph.D. (Lehigh).

Associate professors. Kazuhiko Kasai, Ph.D. (U.C. Berkeley); Peter Mueller, Dr. sc. techn. (ETH, Zurich); Sibel Pamukcu, Ph.D. (L.S.U.); James M. Ricles, Ph.D. (U.C. Berkeley); Richard Sause, Ph.D. (U.C. Berkeley).

Assistant professors. Stephen P. Pessiki, Ph.D. (Cornell); E. Sarah Slaughter, Ph.D. (M.I.T.).

Active emeriti. Lynn S. Beedle, Ph.D. (Lehigh); George C. Driscoll, Ph.D. (Lehigh); Ti Huang, Ph.D. (Michigan); Alexis Ostapenko, Sc.D. (M.I.T.); David A. VanHorn, Ph.D. (Iowa State).

Civil engineering occupies a prominent position as one of the major fields in the engineering profession. Civil engineers are concerned with all aspects of the conception, planning, design, construction, operation, and maintenance of major physical works and facilities that are essential to modern life. Civil engineering projects are typically characterized by extreme size, complexity, durability, and cost. Examples include bridges, buildings, transportation facilities, tunnels, coastal facilities, dams, foundations, waterways, sewerage and sewage treatment facilities, and water supply and purification systems.

The undergraduate program, which leads to the B.S. degree in Civil Engineering, includes a strong base of mathematics and the physical sciences, followed by a broad range of courses in the areas of engineering science and civil engineering analysis and design. In civil engineering, the courses extend across the areas of structural, geotechnical, hydraulic, environmental, and transportation engineering, along with planning, economics, probability and statistics, and measurements. The program is enriched with a series of required and elective courses in the humanities and social sciences. In addition, there are a number of elective opportunities to enable students to pursue specialization in environmental engineering, structural engineering, hydraulic and coastal engineering, and geotechnical engineering. Over the entire curriculum, emphasis is placed on the development of a solid knowledge of civil engineering fundamentals.

Concomitantly, the program is threaded with instruction and opportunities in utilizing the computer, including computer graphics, throughout the field of civil engineering.

The civil engineering program prepares individuals for entry into the engineering profession or for entry into high quality programs of graduate study. With proper selection of electives, students may also prepare for entrance into schools of law or medicine, or into master's-level programs in engineering management or business administration.

For students interested in geological engineering, a five-year program is available, leading to two bachelor of science degrees, in civil engineering and in earth and environmental sciences.
Recommended Sequence of Courses

**freshman engineering year** (see page 45)

**sophomore year, first semester** (17 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 11 or 12 Micro- or Macroeconomics (3)

**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 II (4)
- Phys 22 Introductory Physics Lab II (1)
- HSS Humanities/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 Water Supply and Wastewater Management (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 Humanities/Social Sciences Elec. (3)
- Approved Elective (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 student's academic adviser in the department of civil engineering. A total of 134 credit hours is required for the degree in civil engineering.

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**Undergraduate Courses**

**14. Measurements and Problem Solving in Civil Engineering (4) fall, spring**
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)

**15. Graphics for Civil Engineering (3) fall, 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. Prerequisite: Engr 1. (ES 0), (ED 0)

**104. Readings in Civil Engineering (1-3)**
Study of selected technical papers, with abstracts and reports. May be repeated for credit. Prerequisite: consent of the department chairperson.

**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 I, Math 205. (ES 2), (ED 0)

**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 similitude and modeling of fluid flows. Includes laboratory experiments to demonstrate basic concepts. Prerequisite: Mech 2. (ES 3), (ED 0)

**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.
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 chairperson. (ES 3.5), (ED 0.5)

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 indeterminate structures; modeling for structural analysis; flexibility, stiffness, and approximate methods of analysis of indeterminate structures. Prerequisite: Mech 12. (ES 4), (ED 0)

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)

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)

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)

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 chairperson. (ES 0), (ED 0)

205. **Design Problems (1-6)**
Supervised individual design problems, with report. Prerequisite: consent of the department chairperson.

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)

211. **Research Problems (1-6)**
Supervised individual research problems, with report. Prerequisite: consent of the department chairperson.

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)

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)

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)

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.

244. **Foundation Engineering (3) spring**
Application of the theories and principles of soil mechanics to foundation design. Site investigations and engineering tests to evaluate subsoil conditions. Bearing capacity and settlement analyses for building foundations. Lateral loads on retaining...
walls and bulkheads. Prerequisite: CE 143 or consent of the department chairperson. (ES 2), (ED 1)

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 0.5), (ED 2.5)

259. Structural Analysis II (3) spring
Analysis of statically indeterminate structures, methods of slope deflection and moment distribution; consideration of side-sway 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)

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 1), (ED 2)

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)

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 lecturers from industry. Prerequisite: CE 202 or consent of the department chairperson. (ES 1), (ED 2)

270. Water Supply and Wastewater Management (4) spring
Quantitative and qualitative evaluation of water sources. Transport, storage, purification and distribution of water supplies. Analysis and design of systems for collection and management of spent and excess storm water; wastewater treatment processes for return to the natural ecosystem. Field trips to water and wastewater process facilities. Laboratory determination of water quality parameters and wastewater characterization for incorporation into management practice. Prerequisites: Chem 21, 22 and CE 121. (ES 1), (ED 3)

281. Special Topics (1-6)
A study of selected topics in civil engineering, not included in other formal courses. A report is required. Prerequisite: consent of the department chairperson.

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)

320. Flood Hydrology and Hydraulics (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)

321. Advanced Hydraulics (3) fall
Energy and momentum concepts, frictional resistance in open channels and closed pipelines. Rapidly and gradually varied flow in open channels; unsteady flow in open channels and closed pipelines. Prerequisite: CE 222. (ES 2), (ED 1)

322. Hydromechanics (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)

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.

326. Engineering Groundwater Hydrology (3) spring
The study of subsurface water, its environment, distribution, and movement. Also included are hydraulics of pumping
Soil mineralogy, bonding, crystal structure and surface properties; laboratory and field studies; geotextiles and geomembranes. Prerequisites: CE 143 or equivalent.

345. Environmental Geotechnology (3) fall
Behavior of soil and rock and their interaction with various environmental cycles including the atmosphere, biosphere, hydrosphere, lithosphere and geomicrosphere. Soil-water environments, the geomorphic process of soil/rock, mass transport in polluted moist soils, effect of pollutants on soil behavior and foundations, clay liner, slurry wall design. Prerequisite: CE 143. (ES 2.5), (ED 0.5)

352. Structural Dynamics (3) spring
Analysis of linear structural systems to time-dependent loads. Free and forced vibration. Classical and numerical methods of solution. Lumped-mass techniques, energy methods, and introduction to matrix formulation of dynamic problems. Application to design. Prerequisites: Math 205, CE 159, and Mech 102. (ES 3), (ED 0)

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 multistory frames. Comparison of plastic design techniques with allowable-stress design methods. Current research. Prerequisite: CE 259 or consent of the department chairperson. (ES 2), (ED 1)

360. Bridge Engineering Project (3) spring
Design team approach to the preliminary design and cost analyses of highway bridges in steel, reinforced concrete, and prestressed concrete. Emphasis is on the total design concept, and includes foundations, substructure, superstructure, economy, strength, and performance. Also included are bridge inspection methods, rating evaluations, and retrofit, rehabilitation, and replacement concepts. Prerequisites: CE 261 and CE 263. (ES 0), (ED 3)

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 chairperson. (ES 2), (ED 1)

370. Water and Wastewater Treatment (3) spring
Unit operations and processes in water and wastewater treatment, sedimentation, coagulation, flocculation, filtration, disinfection, chemical treatment, ion exchange, adsorption, biological oxidation, sludge dewatering and stabilization.
Kinetics, reactor theory, mass balances, application of fundamental physical, chemical and biological principles to analysis and design. Prerequisite: CE 270 or equivalent. Kugelman. (ES 1), (ED 2)

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)

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)

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)

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 chairperson.

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 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.

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, or 479). 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. is required to complete an individual engineering project representing three to six credits in place of the thesis or research report required for the M.S. (CE 480).

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 chairperson.

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 apparatus. Included in the latter are the facilities of the NSF-ERC 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 recently expanded hydraulic facilities include a wave tank, several flumes, a 10 cfs recirculating flow system, and two multipurpose tanks for model studies. An interdisciplinary relationship with the Environmental Studies Center facilitates the development of research programs in environmental engineering. 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, geological sciences, and biology may also be considered a part of the major field in civil engineering. A list of such courses is available through the department chairperson.
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 provide 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**

**402. Analytical Methods in Civil Engineering (2)**
Analytical and numerical methods used in various fields of Civil Engineering. Treatment of typical ordinary and partial differential equations in Civil Engineering. Approximation by series. Variational methods, Rayleigh-Ritz, Galerkin, finite element. Finite differences, numerical integration. Problems and examples from the mechanics of solids, fluids, and other Civil Engineering fields. Prerequisite: Math 205 or equivalent.

**407. Computer Methods in Civil Engineering I (3)**
Modular software and data design, code optimization, debugging techniques, file management, software selection, spreadsheet and database management systems. Large systems of linear simultaneous algebraic equations, and eigenvalue problems; data smoothing and splines. Prerequisites: Math 205 or equivalent and working knowledge of FORTRAN-77.

**408. Computer Methods in Civil Engineering II (3)**

**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 417 and CE 407 or equivalent; working knowledge of Fortran.

**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.

**417. Mechanics of Structural Members (4)**

**418. Theory and Methods of Structural Analysis (4)**
Theory and methods of linear and 2nd order structural analysis. Linear theory of structural members, stiffness and flexibility properties, linear transformations of structural analysis. Application of virtual work principles, and development of displacement (stiffness) and force (flexibility) methods of analysis in matrix form suitable for computer solution. Introduction to 2nd order theory of structural members and 2nd order equations of structural analysis, including stability analysis. Prerequisite: CE 159 or permission of instructor.

**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. Prerequisite: consent of instructor.

**424. Surface Water Hydrology (3)**
Advanced analysis and methods in surface water hydrology. Linear and non-linear hydrograph methods. Kinematic wave and other hydraulic routing techniques. Advanced techniques for evaporation, infiltration, snow melt. Prerequisite: CE 325 or equivalent.

**425. Hydraulics of Sediment Transport (3)**

**427. Transport of Contaminants in Groundwater (3)**
Groundwater flow, transport and dispersion of contaminants in the groundwater system, including review of selected biological and chemical reactions such as ion exchange, carbonate equilibrium. Computer-based state-of-the-art groundwater contaminant transport models will be used. Selected case studies will be analyzed. Prerequisite: CE 326 or equivalent.
428. Advanced Topics in Hydraulics (1-3)
Recent developments in hydromechanics and hydraulics. Topics to be selected from: wave mechanics, theory of 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 chairperson. May be repeated for credit.

429. Hydraulic Research (1-6)
Individual research problems with reports. May be repeated for credit.

436. 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 solution of coastal hydrodynamics. Selection of topics will depend on particular qualifications of staff, as well as on the interests of the students. Prerequisite: CE 335. May be repeated for credit.

439. Coastal Engineering Research (1-6)
Individual research problems with reports. May be repeated for credit.

441. Soil Dynamics (3) fall
Vibration of elementary systems, wave propagation, dynamic soil properties, vibration of soils, foundation vibrations, dynamic bearing capacity, dynamic earth pressure problem and retaining wall, liquefaction of soils, earthquake problems. Prerequisite: CE 244 or consent of the department chairperson.

443. Advanced Soil Mechanics I (3) fall
The origin, composition, and physico-chemical properties of soils and their influence on the engineering properties and behavior of soils; transmission of water in saturated and unsaturated soils; advanced theory of compaction; compression and consolidation; theories of shear strength. Prerequisite: a course in soil mechanics.

444. Advanced Soil Mechanics II (3) spring
Fundamental and advanced theories of soil mechanics applicable to earth structures and foundation design; stresses in homogeneous and layered systems for ideal elastic, plastic and visco-elastic soils; lateral earth pressures, thermo-geotechnics. Prerequisite: CE 443.

445. Advanced Foundation Engineering (3) fall
Current theory and practice relating to the design of foundations for buildings and other structures. Analysis and limitation of settlements; bearing capacity analyses of shallow and deep foundations; flexible and rigid retaining structure design; dynamic effects; anchor and other special foundations; site investigations; design criteria for foundations; load and environmental factors. Prerequisite: a course in soil mechanics.

447. Advanced Topics in Geotechnical Engineering (3)
Advanced studies in selected subjects related to geotechnical engineering. The general areas may include: stress-strain-time relationships of soils, colloidal phenomena in soils, ground water flow and seepage, soil dynamics, soil plasticity, numerical methods applied to soil mechanics, earth dam design, theories of layered systems and their application to pavement design, rock mechanics. The studies specifically undertaken in any particular semester depend on the availability of staff and the interest of students. Prerequisite: consent of the department chairperson. May be repeated for credit.

448. Plasticity and Limit Equilibrium in Geotechnical Engineering (3) spring
Application of plasticity in soil mechanics, new concepts and theories and the requirements for modeling of actual test performance of soils, plastic yielding/failure criteria, constitutive relations of stress-strain-time, concepts of critical state soil mechanics, rheological performance, application to problems of stability of slopes, bearing capacity of foundations and active/passive earth pressures. Prerequisite: CE 244, or consent of the department chairperson.

449. Geotechnical Research (1-6)
Individual research problems relating to soil engineering, with report. Prerequisite: a course in soil mechanics.

451. Advanced Structural Theory (3) fall

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.

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 instability. Desirable preparation: Mech 415. Prerequisites: CE 402, CE 407, and consent of the department chairperson.

454. Plate and Shell Structures (3)
407, and consent of the department chairperson.

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 aeroelasticity and seismic forces and nuclear blast. Introduction to vibration of three-dimensional structural systems. Prerequisites: CE 402, CE 407, CE 352 or Mech 406, and CE 418 or equivalent.

456. Behavior and Design of Earthquake Resistant Structures (3)

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.

458. Repair and Retrofit of Steel Structures (3)
Various types of construction problems experienced during the 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.

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.

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.

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.

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.

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 chairperson.

466. Concrete Shell Structures (3)

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 chairperson. May be repeated for credit.

468. (Mech 415) Stability of Elastic Structures (3)

469. Structural Research (1-6)
Individual research with reports. May be repeated for credit.

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.

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.

472. Waste Water Treatment Facilities (3)
Theory and design of water pollution control systems. Emphasis on film flow and suspended growth biological reactors for organic and nutrient removal. Sludge production, stabilization, dewatering and ultimate disposal. Prerequisite: CE 370 or equivalent.

473. Advanced Treatment Processes in Environmental Engineering (3)
Adsorption, ion exchange, reverse osmosis electrodialysis chemical oxidation and stripping in water and wastewater treatment. Kinetics, reactor theories and modeling in water and wastewater treatment systems. Prerequisite: CE 470 or equivalent.

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.

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, speciality conference attendance. Prerequisite: Department chairperson approval.

476. Environmental Engineering Microbiology (3)
Fundamentals of microbiology and biochemistry applied to environmental systems and water quality control. Systems ecology, energetics and kinetics of microbial growth, nutrition and toxicology, use of microorganisms for pollution monitoring and control. Pathogenicity and disease transmission, water quality using biological indices. Prerequisite: CE 370 or a suitable course in Biology.

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.

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.

479. Environmental Engineering Research (1-6)
Individual research problems in environmental engineering with report. May be repeated for credit.

480. Civil Engineering Project (1-6)
an intensive study of one or more areas of civil engineering, with emphasis on engineering design and applications. A written report is required. May be repeated for credit.

481. Special Problems (1-6)
an intensive study, with report, of a special field of civil engineering which is not covered in the other courses. A design project or an interdisciplinary study of a problem related to civil engineering may also be included. May be repeated for credit.

483. Graduate Seminar (1-3)
Study of current topics in civil engineering.

491. Thesis (1-6)

499. Dissertation (1-15)
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. On the other hand, 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 undergraduate officer in the department of civil engineering.

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<th>freshman engineering year (see page 45)</th>
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<th>second year, first semester (16 credit hours)</th>
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<tr>
<td>Math 23 Analytic Geometry and Calculus III (4)</td>
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<td>Mech 2 Elementary Engineering Mechanics (3)</td>
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<td>Chm 31 Chemical Equilibria in Aqueous Systems (3)</td>
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<td>EES 101 Geology for Engineers (3)</td>
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<td>CE 15 Graphics for Civil Engineering (3)</td>
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<th>second year, second semester (18 credit hours)</th>
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<td>Phy 21 Introductory Physics II (4)</td>
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<td>Phy 22 Introductory Physics Laboratory II (1)</td>
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<td>Mech 12 Strength of Materials (3)</td>
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<td>EES 113 Life and Climate in the Rock Record (3)</td>
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<td>Math 205 Linear Methods (3)</td>
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<td>CE 14 Measurements and Problem Solving in Civil Engineering (4)</td>
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<th>third year, first semester (16 credit hours)</th>
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<td>CE 121 Mechanics of Fluids (3)</td>
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<td>CE 143 Soil Mechanics (4)</td>
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<td>EES 122 Introduction to Plate Tectonics (3)</td>
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<td>EES 133 Introduction to Mineralogy (3)</td>
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<td>Mat 192 Structural Materials (3)</td>
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<th>third year, second semester (19 credit hours)</th>
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<td>CE 117 Numerical Methods in Civil Engineering (2)</td>
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<td>CE 222 Hydraulic Engineering (4)</td>
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<td>CE 270 Water Supply and Wastewater Management (4)</td>
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<td>EES 134 Introduction to Optical Mineralogy and Crystallography (3)</td>
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<th>fourth year, first semester (18 credit hours)</th>
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<tr>
<td>CE 203 Professional Development (2)</td>
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<td>CE 159 Structural Analysis I (4)</td>
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<td>EES 135 Introduction to Lithology and Petrography (3)</td>
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<td>EES 213 Sedimentology and Stratigraphy (3)</td>
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<td>EES 223 Structural Geology (3)</td>
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<td>EES 316 Hydrogeology (3)</td>
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<tr>
<th>fourth year, second semester (16 credit hours)</th>
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<tr>
<td>CE 160 Structural Design (4)</td>
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<tr>
<td>**Engineering Science Elective (3)</td>
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<tr>
<td>EES 112 Geomorphology (3)</td>
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<tr>
<td>EES 307 Case Histories in Engineering Geology (3)</td>
</tr>
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<td>HSS Humanities/Social Sciences Elective (3)</td>
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<tr>
<th>summer (6 credit hours)</th>
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<tr>
<td>EES 341 Field Geology (6)</td>
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<tr>
<th>fifth year, first semester (18 credit hours)</th>
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<tbody>
<tr>
<td>CE 202 Civil Engineering Planning and Engineering Economics (3)</td>
</tr>
<tr>
<td>EES 301 Introduction to Geophysics (3)</td>
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<tr>
<td>EES 373 Geochemical Thermodynamics (3) or Chm 187 Physical Chemistry (3)</td>
</tr>
<tr>
<td>CE *Civil Engineering Elective (3)</td>
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<tr>
<td>HSS Humanities/Social Sciences Elective (6)</td>
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<tr>
<th>fifth year, second semester (15 credit hours)</th>
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<tbody>
<tr>
<td>CE 207 Transportation Engineering (3)</td>
</tr>
<tr>
<td>CE 290 Civil Engineering Design Project (3)</td>
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<tr>
<td>CE *Civil Engineering Elective (3)</td>
</tr>
<tr>
<td>HSS Humanities/Social Sciences Electives (6)</td>
</tr>
</tbody>
</table>

**Mech 102, ME 104, or ECE 81.

*Elective that requires approval of the Civil Engineering Department Chairperson.

A total of 172 credit hours is required to earn both degrees.
Classical Studies

Associate professors. Barbara Pavlock, Ph.D. (Cornell), head of the 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 fifteen credit hours. Students may focus on any aspect of classical studies, either singly or in combination. The department can arrange individual programs.

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 concentrate either in classical archaeology or classical literature while gaining an overview of Greco-Roman culture. A minimum of thirty to thirty-three credit hours depending upon previous preparation in language study, required for this major.

Concentration in Archaeology
Clss 112 (Anth 112) Doing Archaeology (3)
Clss 174 (Anth 174) Greek Archaeology (3)
Art 174 (Arch 174)
Clss 176 (Anth 176) Roman Archaeology (3)
Art 176 (Arch 176)
Clss 345 (Anth 345) Evolution of the State (3)

any two courses in ancient history

Two courses chosen from any of the remaining classics course offerings, Anth 11, or Anth 12.

The student taking this concentration must demonstrate linguistic competence by passing either a Latin or Greek course on the intermediate or advanced level.

The program is connected with several excavation and survey projects in the Mediterranean, which the student is strongly encouraged to attend. Some financial support is available. The program additionally directs a local ethnoarchaeological project, in which students in Clss 112 participate.

Concentration in Literature
Three out of the following classes in literature (9)
Clss 52 (Engl 52) Classical Epic (3)
Clss 54 (Engl 54) Greek Tragedy (3)
Clss 56 (Engl 56) Ancient Novel (3)

any two courses in ancient history

one course in either Latin or Greek on the intermediate or advanced level (3)

three courses taken from either the offerings of the Classics program or from approved collateral courses in English, Modern Foreign Languages, or other related areas.
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 thirty to thirty-three credit hours, depending upon previous language study, 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 two electives from the remaining Classics offerings

Courses in Classical Civilization (Clss)
Clss 5. Mythology (3) fall
Introductory study of the myth-making process, both ancient and modern; emphasis on Greek myth.

Clss 21. (Hist 21) Greek History (3) fall
The development of civilization from palaeolithic 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

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

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

Clss 54. (Engl 54) Greek Tragedy (3)
Aspects of Greek theater and plays of Aeschylus, Sophocles, and Euripides in their social and intellectual contexts. Pavlock

Clss 56. (Engl 56) The Ancient Novel (3)
Examination of the origins of the novel in Greece and Rome. Includes the picaresque novel. Pavlock

Clss 58. (Engl 58) Greek and Roman Comedy (3)
Study of comedy as a social form through plays of Aristophanes, Menander, Plautus, and Terence. Pavlock

Clss 74. (Anth 74) 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

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.

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. Small

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. Small

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 economies, politics, social organization, and religion. Small

Clss 131. (Phil 131) Ancient Philosophy (3) fall
Historical study of philosophy in the classical world from the pre-Socratics to Plato, Aristotle, and the Neo-Platonists, as the originators of the western tradition in philosophy and as interacting with the religious, political, and scientific life of their times.

Clss 152. Women in Antiquity (3)
Interdisciplinary study of women in Greece and Rome. Literary, archaeological and historical evidence and approaches. Cross-cultural material.

Clss 161. Roman Law (3)
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

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

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

Class 178. (Anth 178) Mesoamerican Archaeology (3)
Ancient civilizations of Mesoamerica: Olmec, Zapotec, Maya, Toltec, and Aztec. Reconstructions of urban centers, political and economic organizations, and theories of Mayan collapse. Small

Class 201. (Art 201) Archaeology: Lands of the Bible (3)
Chronological survey of archaeological finds from Palaeolithic, Neolithic, Bronze Age, Iron Age, and late cultures in the Near East. Material illustrating the cultures and events of the Bible.

Class 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

Class 213. (Rel 213) Ancient Roman Religion (3)

Class 214. (Hist 214) Age of Caesar and Christ (3)
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

Class 215. (Hist 215) Decline and Fall of the Roman Empire (3)
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. Phillips

Class 220. (Hist 220) Golden Age of Greek Democracy (3)
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.

Class 251. (Rel 251) Classical Mythology (3)

Class 281. Readings (3)
Advanced study of a historical period or theme. Emphasis on primary sources. Prerequisite: Class 21 or 22 and consent of the department chairperson.

Class 282. Readings (3)
Advanced study of a historical period or theme. Emphasis on primary sources. Prerequisite: Class 21 or 22 and consent of the department chairperson.

Class 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. Small

Courses in Ancient Greek

Greek 1. Elementary Ancient Greek (3)
Fundamentals of the Greek language. Readings in the easier authors. Staff

Greek 2. Elementary Ancient Greek (3)
Continued work in Greek vocabulary, forms, and syntax. Selected readings in Greek. Prerequisite: Greek 1. Staff

Greek 11. Intermediate Ancient Greek (3)
Readings in Herodotus, Homer, or Xenophon. Grammar review. Prerequisite: Greek 1 and 2, or one year of entrance Greek, or consent of department chairperson.

Greek 12. Intermediate Ancient Greek (3)
Plato: Euthyphro, Apology and Crito, or other dialogues. Prerequisite: Greek 11.

Greek 111. Greek Drama (3)
Representative plays of Sophocles, Euripides and Aristophanes. Literary study of the drama. Prerequisite: Greek 12.

Greek 112. Greek Drama (3)
Continuation of Greek 111. Prerequisite: Greek 12.

Greek 113. Greek Historians (3)
Selections from Herodotus, Thucydides or Xenophon. Study of Greek historiography. Prerequisite: Greek 12.

Greek 271. Readings (3)
Intensive readings in one author or in a selected genre. Prerequisite: six credit hours at the 100 level and consent of the department chairperson.

Greek 272. Readings (3)
Intensive readings in one author or in a selected genre. Prerequisite: six credit hours of courses at the 100 level and consent of the department chairperson.
Courses in Latin

Lat 1. Elementary Latin (4) fall

Lat 2. Elementary Latin (3) spring
Easy Latin prose and poetry. Prerequisite: Lat 1 or one to two years of entrance Latin.

Lat 11. Intermediate Latin (3) fall
Readings in Latin prose or poetry. Consolidation of reading ability; introduction to literary analysis. Prerequisite: Lat 2 or consent of department chairperson.

Lat 12. Intermediate Latin (3) spring
Readings in Latin prose or poetry. Consolidation of reading ability; introduction to literary analysis. Prerequisite: Lat 2 or consent of department chairperson.

Lat 111. Catullus and Horace (3)
Translation and analysis of selected lyrics, focusing on imagery systems. Introduction to metrics. Prerequisite: Lat 12 or consent of department chairperson.

Lat 112. Republican Prose: The Roman Revolution (3)
Letters of Cicero; Sallust's Catiline. Prerequisite: Lat 12 or consent of chairperson.

Lat 113. Vergil (3)
Selections from the Aeneid. Vergil's creation of a Latin epic and its ambiguities. Metrics. Prerequisite: Lat 12 or consent of chairperson.

Lat 114. Livy (3)
Selections from the early books of Livy's histories focusing on his creation of a Roman mythos. Style. Prerequisite: Lat 12 or consent of chairperson.

Lat 115. Ovid (3)
Selections from the Ars Amatoria and Metamorphoses 6-10, focusing on Ovid's problem with ideology. Metrics. Prerequisite: Lat 12 or consent of department chairperson.

Lat 116. Petronius (3)
Selections from the Satyricon, focusing on language usage and epic travesty. Prerequisite: Lat 12 or consent of chair.

Lat 211. Readings (3) fall
Intensive readings in one author or in a selected genre. Prerequisite: six hours of courses at the 100 level and consent of the department chairperson.

Lat 212. Readings (3) spring
Intensive reading in one author or in a selected genre. Prerequisite: six hours of courses at the 100 level and consent of the department chairperson.

Lat 303. The Roman Epic (3)
The epic in Latin literature; selections from Lucretius, Catullus and Ovid; critical study of Vergil's Aeneid. Prerequisite: six hours of courses at the 100 level and consent of the department chairperson.

Cognitive Science

Mark H. Bickhard, Ph.D. (U. of Chicago), director, Cognitive Science Program; 758-3633; MBHo.

Cognitive science is the interdisciplinary study of the relationship between 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 anthropology, psychology, computer science, linguistics, and philosophy.

The College of Arts and Sciences offers a major in Cognitive Science, as well as a 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, or computing science who have overlapping interests in cognitive science.

The B.A. with a major in Cognitive Science requires a minimum of 43 credit-hours: 36 within the major itself and at least 7 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 six elective courses, two in each of three topical areas related to cognitive science. The final integration of coursework occurs in the required senior seminar, in which students focus on a topic of their choice from a branch of cognitive science.

The collateral course requirements include Math 9 Introduction to Finite Mathematics, Fall), CSc 11 Introduction to Structured Programming, CSc 15 Data Structures, CSc 17 Structured Programming and Data Structures, CSc 261 to satisfy the major electives requirement should take Math 21 (a prerequisite of CSc 261) in place of Math 9. Additional coursework in mathematics is strongly recommended, as are: Psychology 1 or 11, Biology 31 and 32, and Anthropology 12.
Description of Courses

**Required Introductory Course**

- CogS 7 Introduction to Cognitive Science (3) spring

**Collateral Requirements** (7-9 hours)

- Math 9 Introduction to Finite Mathematics (3)
- CSc 11 Introduction to Structured Programming (3) and
- CSc 15 Data Structures (4) or
- CSc 17 Structured Programming and Data Structures (4)

**Disciplinary Core Courses** (12 hours)

- CSc 327 Artificial Intelligence Applications (3)
- Phil 250 The Minds of Men and Robots (3)
- Psyc 117 Cognitive Psychology (3)
- CogS 140 (Mfl 140; Introduction to Linguistics (3)
  Psyc 140; Anth 140)

**Major Electives** (18 hours)

After completing the introductory sequence and the four core courses, students must complete two courses from any three of the following groups.

**Artificial Intelligence and Expert Systems:**
- CSc 262 Programming Languages (3)
- CSc 365 Natural Language Understanding (3, prereq: CSc 262)
- CSc 368 Artificial Intelligence (3, prereq: CSc 262)

Students who qualify may take

- CSc 413 Robotics and Intelligence Machines (3), or
- CSc 463 Computational Linguistics (3)

**Formal Models:**
- Phil 114 Fundamentals of Logic (3)
- Phil 214 Logical Theory (3)
- CSc 261 Discrete Structures (3, prereq: Math 21 and either CSc 11 or Eng 1)
- CSc 318 Automata and Formal Grammars (3, prereq: CSc 261)

**Philosophy:**
- Phil 139 Contemporary Philosophy (3)
- Phil 220 Knowledge and Justification (3)
- Phil 251 Action, Free Will, and Fate (3)

**Cognitive Psychology:**
- Psyc 307 Seminar in Cognition (3, prereq: Psyc 117)
- Psyc 320 Psycholinguistics (3)
- Psyc 351 Cognitive Development in Childhood (3, prereq: Psyc 107 or Psyc 117)

**Sociocultural Influences on Cognition:**
- SSP 135 Human Communication (3)
- SSP 307 Attitudes, Attritions, and Actions (3)
- Anth 376 Mind, Self and Culture (3)

**Neuroscience:**
- Psyc 176 Introduction to Cognitive Neuroscience (3)
- Psyc 177 Introduction to Physiological Psychology (3)
- Psyc 373 Sensation and perception (3, prereq: Psyc 176)
- Psyc 375 Neuroanatomy of Behavior (3, prereq: Psyc 177)

**Senior Seminar** (3 hours)

After completing the sophomore introductory sequence and the four major 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**
  - CogS 7 (spring)
- **Sophomore**
  - 2 Core Courses
  - CSc 11 & 15 or CSc 17
  - Math 9
- **Junior**
  - 2 Core Courses
  - Major electives
- **Senior**
  - Major electives
  - CogS 301 (spring)

**Minor In Cognitive Science**

The minor in Cognitive Science requires the following courses:

- CogS 7 Introduction to Cognitive Science
- Math 9 Introduction to Finite Mathematics or CSc 261 Discrete Structures
- CSc 327 Artificial Intelligence Applications
- Phil 250 The Minds of Men and Robots
- Psyc 117 Cognitive Psychology
- CogS 140 Introduction to Linguistics
Course Descriptions

7. **Introduction to Cognitive Science (3)** spring
What is a mind? How is the mind related to the brain? Could make an artificial mind? Issues concerning knowledge representation and intelligence in minds and computers as investigated by psychologists, philosophers, linguists, neuroscientists, and researchers in artificial intelligence.

140. (Mfl 140; Psych 140; Anth 140) **Introduction to Linguistics (3)**
Relationship between language and mind; formal properties of language; language and society; how languages change over time.

301. **Senior Seminar in Cognitive Science (3)** spring
Integration of the material from cognitive science on topics chosen by the students.

478. (Psych 478) **Ontological Psychology (3)**
Principles and constraints for modeling psychological phenomena. Representation; perception; memory; knowing; learning; emotions; consciousness; language; rationality.

Roy Eckardt College Scholar Program

**Director.** Ian Duffy, professor of history.

**Advisory Committee.** Mark Bickhard, professor of psychology; Bobb Carson, professor of earth and environmental sciences; Beall Fowler, professor of physics; Edward Gallagher, professor of English; Lucye Gans, professor of art and architecture; Norman Girardot, professor of religion studies; Charles Krailhanel, professor of chemistry; Norman Melchert, professor of philosophy.

For program requirements, see page 29.

389. **Honors Project for College Scholars (1-6)**
Opportunity for College Scholars to pursue an extended project for senior honors. May be repeated for credit. Transcript will identify department in which project was completed. Prerequisite: consent of department chairperson.

C.S. 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 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**

Certain departments offer limited 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 the non-credit course, Cooperative Undergraduate Education, to maintain continuous 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.

Details of cooperative arrangements vary with different curricula. Each department offering cooperative education will provide the details of its program in writing to interested students.

200. **Cooperative Undergraduate Education (0)**
Supervised cooperative work assignment to obtain practical experience. Prerequisite: consent of the department chairperson.
Counseling

See listings under Education.

Design

Program director: Richard Roberts, Ph.D. (Lehigh), professor of mechanical engineering and mechanics.

Program faculty: Alden S. Bean, Ph.D. (Lehigh), Wm. R. Kenan, Jr., professor of management and technology; Keith M. Gardiner, Ph.D. (Manchester, England), professor of industrial and manufacturing systems engineering; Ben Marcune; John Ochs, Ph.D. (Penn State), professor of mechanical engineering and mechanics; Tom F. Peters, M.Arch ETH Zurich (dipl.Arch.ETH) and Dr.sc. (Techn.) ETH Zurich, professor of art and architecture; George Shortess, Ph.D. (Brown), professor emeritus psychology; Ricardo Viera, M.F.A. (R.I.S.D.) professor of art and architecture; Ivan Zaknic, M.Arch. And Urban Planning (Princeton), professor of art and architecture.

The Master of Science in Design Program is built upon an undergraduate engineering degree. It is anticipated that with similar programs will develop for students with degrees from undergraduate arts or business programs. The curriculum is technological in nature, emphasizing design practice, design history, and design communication. It also focuses on issues related to aesthetics, business communication, management of people and technology, mathematics and modeling, manufacturing and manufacturing methods. The program requires at least 30 credit hours of graduate level work as set forth below.

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<tr>
<th>Course</th>
<th>Credits</th>
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<tr>
<td>Design Studio</td>
<td>6</td>
<td>Provides major design experience and commentary on behavioral issues. Work on real design problems from industry and government.</td>
</tr>
<tr>
<td>MSE 423. Product Design &amp; Analysis</td>
<td>3</td>
<td>Provides modeling and math skills</td>
</tr>
<tr>
<td>MSE 431. Technological Innovation</td>
<td>3</td>
<td>Provides management/business skills in Manufacturing Organization</td>
</tr>
<tr>
<td>MSE 427. Production Systems</td>
<td>3</td>
<td>Provides manufacturing skills</td>
</tr>
<tr>
<td>MAT 458. Design</td>
<td>3</td>
<td>Provides materials application and materials processing skills</td>
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Electives 9 To be selected in consultations with an advisory committee

TOTAL 30

Graduate Courses

Design Studio (6) The Design Studio affords students and faculty the opportunity to collaborate on design related problems. The studio experience, which is the equivalent of a six-credit thesis, is modeled after the design studio concepts used by the Department of Art and Architecture. Students in this program are expected to provide designs in response to problem/need statements and to defend the solutions both in writing and orally. Faculty feedback is provided to students relative to the design and the effectiveness of the written and oral presentation. The critiques are offered by the "Design Faculty" from the Colleges of Engineering & Applied Science, Business and Economics, and Arts and Sciences. As part of this process, faculty discuss the pros and cons of the specific design, as well as the design process or processes used for producing the designs. These discussions are an ongoing part of the design studio and afford students the opportunity to reflect on the design process and how is should be executed in real worlds situations. As appropriate and as needed, personnel from industry and government are asked to participate in the review/critique process. Regular design meetings and seminars are used to provide input to this process and to provide continuity for the students over the course of their studio experience.

ART 395. Rendering/Industrial Design Skills (3)

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.

MSE 423. Product Design & Analysis (3)
Provides an 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. The course includes case studies and design assignments.

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 methods for a new product; computer-aided process planning, group technology, robotics, numerical control, and other automated manufacturing methods are included in this course.
Earth and Environmental Sciences

Professors. Bobb Carson, Ph.D. (Washington); Edward B. Evenson, Ph.D. (Michigan); Kenneth P. Kodama, Ph.D. (Stanford), chairperson; Paul B. Myers, Jr., Ph.D. (Lehigh); Craig E. Williamson, Ph.D. (Dartmouth).

Associate professors. David J. Anastasio, Ph.D. (Johns Hopkins); Bruce R. Hargreaves, Ph.D. (U.C., Berkeley); Anne S. Meltzer, Ph.D. (Rice); Carl O. Moses, Ph.D. (Virginia); Peter K. Zeitler, Ph.D. (Dartmouth).

Assistant professors. Gray E. Bebout, Ph.D. (U.C., Los Angeles); Donald P. Morris, Ph.D. (Colorado).

Visiting assistant professor. Eugene S. Itlon, Ph.D. (Johns Hopkins).

The Department of Earth and Environmental Sciences offers undergraduate and graduate degree programs in Geological Sciences and Environmental Sciences. An undergraduate degree program in Geophysics is also available. Faculty in the department have specialized expertise in diverse fields and can offer students the broadly based education that will be required to work or conduct research in the earth and environmental sciences.

Environmental Science

Environmental systems, consisting of air, water, solid Earth materials, and life, have existed, interacted, and coevolved for billions of years. Humans are relative newcomers to Earth’s surficial environment, but the intensity of our interaction with the environment far exceeds that of other species. Environmental science is an emerging field of study that draws on all of the traditional scientific disciplines and adds to them its specific purpose: to understand environmental systems and the processes through which they interact. The primary task of environmental scientists is to develop a conceptual framework for studying and understanding the environment.

The environmental science curricula offered by Lehigh are intended to help students focus their curiosity about the environment on the study of current human understanding of environmental systems and to engage students in the ongoing processes of developing the framework for understanding the environment and making new discoveries that advance that understanding. Lehigh offers two undergraduate majors in environmental science, one leading to a bachelor of science degree and one leading to a bachelor of arts degree. Our degree programs are designed to ensure a firm foundation in mathematics, communication skills, and the traditional sciences (chemistry, physics, geology, and biology), to provide a breadth of understanding of environmental systems, and to develop a depth of competence in the individual student’s chosen area of specialization. Ultimately as one becomes an environmental scientist, one’s educational experience must include direct interaction with the environment, and our degree programs require a component of experiential learning. This requirement can be satisfied through field courses, research participation, or internships, for example. Participation in research is especially encouraged, and course credit for research projects can be easily arranged. During the spring semester of the senior year, all environmental science students participate in a seminar that integrates the entire curriculum through discussion of current issues on the forefront of environmental science. Students considering a major in either curriculum are urged to contact the undergraduate advisor for environmental science majors in the department.

A minor in environmental science 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.

A degree in environmental science prepares a student for graduate study in environmental science, other fields of science or engineering, education, law, medicine, business or other areas, depending on one’s interests and choice of electives. Employment opportunities exist in a number of fields, including consulting firms, manufacturing companies, natural resource corporations, financial institutions, government agencies, schools, and lobbying and advocacy groups.
Major requirements for a B.S. in Environmental Science
A total of 121-125 credit hours are required.

college and university requirements (28 credit hours)
Engl 1 Composition and Literature (3)
Engl 2, 4, 6, 8, or 10
Arts & Science 1 Choices and Decisions (1)
FS 90 College Seminar (1st yr.) (3)
Electives (9 cr. humanities, 9 cr. social science) (18)

major program (48-56 credit hours)
Introduction Sequence of Courses (8-10 credit hours)
EES 21 Introduction to Earth Materials and Processes (4) or
EES 41 Physical Geology and Geomorphology in the Rocky Mountains (6) and
EES 31, 32 Intro to Environmental and Organic Biology and Lab (4)

collateral sciences (32 credit hours)
Chm 21, 22 Introductory Chemistry and Laboratory (5)
Chm 31 Chemical Equilibria in Aqu. Systems (3)
Chm 51 Organic Chemistry I (3)
Math 21, 22, 23 Calculus I, II, III (12)
Phy 11, 12, 13, 14 Intro to general physics and lab (9)

Introductory core course
EES 181 Introduction to Environmental Science (4)

Breadth and skills requirement (15-17 credit hours)
Choice of two earth systems courses (6)
Earth Systems
EES 112 Geomorphology (3)
EES 113 Paleontologic Evidence for Earth Evolution (3)
EES 122 Introduction to Plate Tectonics (3)
EES 131 Introduction to Rocks and Minerals (3)
EES 213 Sedimentology and Stratigraphy (3)
EES 223 Structural Geology (3)

Choice of two life systems courses (6-8)
Life Systems
MBio 31, 32 Introduction to Cell and Molecular Biol and lab (4)
MBio 101, 102 Genetics and lab (4)
BEB 134 Comparative Vertebrate Anatomy (4)
EES 251, 252 Ecology and lab (4)
Statistics: Math 231 or EES 382 (3)

specialization requirement (12-16 credit hours)
Choice of four courses at the 300 level, three of which are EES courses. The student must submit to the adviser to the ES major a written justification of how the four courses selected serve to increase the student's depth of competence in some area. This written statement must be filed no later than the time of preregistration for the first semester of the senior year.

approved professional electives (6 credit hours)
At least two courses chosen to support the professional objectives of the student, subject to approval by the adviser to the ES major. Professional electives must be at the 200 level or above in the department and at the 100 level or above in other departments.

advanced core seminar (3 credit hours)
EES 381 Senior Seminar in Environmental Sciences (3)

free electives (6-12 credit hours)
Courses chosen from anywhere in the University's curriculum to bring total credits of program to 121. Minimum of 4 credits.

Additional Requirements
Laboratory requirement. At least six laboratory courses, at least two of which are at the 200 level or above.

Field experience requirement. Approved field experience: i.e. EES 41; EES 341; or approval by the adviser to the ES major for the equivalent of three credit hours of field experience in the form of a field course at another institution, a field research project, or a work experience.

Recommended Sequence of Courses

Fall
Engl 1 (3) Engl 2 (3)
EES 21 (4) EES 31, 32 (4)
Math 21 (4) Math 22 (4)
College Seminar (3) Chm 21, 22 (5)
A & S 1 (1)

Spring
Engl 2 (3)
B & S Earth Sys. (3)
Phy 11, 12 (5) B & S Life Sys. (3-4)

sophomore year
Math 23 (4) EES 181 (4)
College Elec. (3) Phys 13, 14 (5)
Chm 31 (3) B & S Earth Sys. (3)
Phy 11, 12 (5) B & S Life Sys. (3-4)

junior year
College Elec. (3) College Elec. (3)
Chm 51 (3) Spec. Req. 3xx (3-4)
B & S Earth Sys. (3) Spec. Req. 3xx (3-4)
B & S Life Sys. (3-4) Prof. Elec. (3)
EES 382 (3) Prof. Elec. (3)
or Math 231 (3)
**Summer**  
Summer field experience*  

### senior year  
- College Elec. (3)  
- Spec. Req. 3xx (3-4)  
- Spec. Req. 3xx (3-4)  
- College Elec. (3)  
- Free Elec. (3)  

### B.A. in Environmental Science  
A total of 121-126 credit hours is required.

#### college and university requirements (28 credit hours)  
- English Composition (6)  
- Arts and Science 1 (1)  
- College Seminar (1st yr.) (3)  
- Electives  
  - (min. 9 cr. social sciences)  
  - (min. 9 cr. humanities) (18)  

#### Major program (51-62 credit hours)  
**Introductory Sequence of Courses** (8-10 credit hours)  
- EES 21 Introduction to Earth Materials and Processes (4)  
- EES 41 Physical Geology and Geomorphology in the Rocky Mountains (6)  
- EES 31, 32 Intro to Environmental/Organismal Biology and laboratory (4)  

**Collateral sciences** (16-18 credit hours)  
- Chm 21, 22 Introductory Chemistry and laboratory (5)  
- Math 41, 44 Calculus I, II (3-4) or  
- Math 21, 22 Analytic Geometry and Calculus I, II (3-4)  
- Phy 11, 12 Intro Physics and laboratory (5)  

**Introductory core course**  
- EES 181 Intro to Environmental Science (4)  

**Breadth and skills requirement** (15-17 credit hours)  
Choice of two earth systems courses (6)  

**Earth Systems**  
- EES 112 Geomorphology (3)  
- EES 113 Paleontologic Evidence for Earth Evolution (3)  
- EES 122 Introduction to Plate Tectonics (3)  
- EES 131 Introduction to Rocks & Minerals (3)  
- EES 213 Sedimentology and Stratigraphy (3)  
- EES 223 Structural Geology (3)  

Choice of two life systems courses (6-8)  

**Life Systems**  
- MBio 31, 32 Introduction to Cell and Molecular Biology and lab (4)  
- MBio 101, 102 Genetics and lab (4)  
- EB 134 Comparative Vertebrate Anatomy (4)  
- EES 251, 252 Ecology and lab (4)  

**Statistics:**  
- Math 12 Statistical Methods (3) or  
- Math 231 Probability and Statistics (3) or  
- EES 382 Statistical Applications (3)  

**specialization requirement** (9-12 credit hours)  
Choice of at least three courses at the 300 level, two of which are EES courses. The student must submit to the adviser of the ES major a written justification of how the three courses selected serve to increase the student's depth of competence in some area. This written statement must be filed no later than the time of preregistration for the first semester of the senior year.  

**Electives in the major** (12-16 credit hours)  
At least four courses at the 100-level or above in the department or related courses in math, science, or engineering.  

**Free electives** (minimum of 18 credit hours)  
Courses chosen from anywhere in the University’s curriculum, including courses in EES, to bring total credits in the major to 121.  

**Advanced core seminar** (3 credit hours)  
- EES 381 Senior Seminar in Environmental Sciences (3)  

**Additional requirements for graduation, B.A.**  
Laboratory requirement. At least six laboratory courses, at least two of which are at the 200 level or above.  

Field experience requirement. Approved field experience: i.e. EES 41; EES 341, or approval by the adviser to the ES major for the equivalent of three credit hours of field experience in the form of a field course at another institution, a field research project, or a work experience.
Recommended Sequence of Courses

Fall  
**freshman year, fall**  
Engl 1 (3)  
A & S I (1)  
College Sem. (3)  
Math 41 or Math 21 (3-4)  
Soc. Sci. Dist. (3)

**freshman year, spring**  
Engl 2 (3)  
Math 44 or 22 (3-4)  
Phy 11, 12 (5)  
EES 31, 32 (4)  
Elec. in the Maj. (3-4)  
Spec. Reg. 3xx (3 -4)

**sophomore year**  
EES 21 (4)  
Soc. Sci. Dist. (3)  
Chm 21, 22 (5)  
Free Elec. (3)  
Free Elec. (3)

**junior year**  
EES 382 or Math 12 (3)  
B & S Earth Sys (3)  
Spec. Reg. 3xx (3-4)  
Elec. in the Maj. (3-4)  
Free Elec. (3)  
Free Elec. (3)

**summer**  
Summer field experience*

**senior year**  
Spec. Req. 3xx (3-4)  
EES 381 (3)  
Free Elec. (3)  
Free Elec. (3)  
Free Elec. (3)

*See major program listing for alternatives

Environmental Science Minor

(18-21 credit hours)

**Introductory sequence (8-10 credit hours)**
EES 21  
EES 41  
EES 31, 32

**Introductory core course**
EES 181

**Breadth and skills requirement (6-7 credit hours)**
Choice of one earth systems course (3)

**Earth Systems**
EES 112  
EES 113  
EES 122  
EES 131  
EES 213  
EES 223

Choice of one life systems course (3-4 credit hours)

**Life Systems**
MBio 31, 32  
MBio 101, 102  
EES 162  
EES 163  
EBB 134  
EES 251, 252

Geological Sciences

Geology, geophysics, and geochemistry deal with natural phenomena on or within the earth. Each makes use of other more fundamental sciences in its practice; hence, the student preparing for a career in one of the geological sciences combines study in earth science with a broad understanding of physical, chemical, and biological principles.

Lehigh offers two undergraduate majors in geological sciences, one leading to the degree of bachelor of science, the other to the degree of bachelor of arts. The bachelor of science curriculum is designed to permit a concentration in depth in the major whereas the bachelor of arts curriculum provides the opportunity for a broad liberal-arts education centered around geoscience. If the electives in the bachelor of arts program are selected carefully, the B.A. program provides the opportunity for (1) a minor in an area of the humanities and social sciences; and (2) entry into graduate-level studies in fields such as geology, environmental science, marine science, environmental law, etc. Students contemplating a major in either curriculum are strongly urged to discuss the selection of electives, collateral sciences, career goals, and job opportunities with the undergraduate advisers in the department.

The bachelor of arts program requires fewer credits for graduation (121-124 vs. 126 credit hours), and fewer courses in collateral sciences and mathematics (20-22 vs. 33 credit hours). Candidates for the bachelor of science degree are required to take fifteen credit hours in approved professional electives. The professional electives permit the student to arrange for an informal concentration in geochemistry, geophysics, hydrogeology, etc. Major electives in the B.A. curriculum provide a similar opportunity for concentration, but comprise 12, rather than 15 credit hours.

Students electing the bachelor of arts program are required to meet the distribution requirements of the College of Arts and Science; candidates for the bachelor of science degree must take eighteen credit hours of nonprofessional electives in place of the distribution requirements.

All geological sciences majors are strongly encouraged to undertake an undergraduate research project during their senior year. Normally, students register for 3-6 credit hours of geological research (EES 291), and work on a field/ laboratory problem in close cooperation with an individual faculty member. Students contemplating a research project should discuss potential areas of research with appropriate faculty at least one semester before registering for geological
research, preferably in their junior year.

Both the bachelor of science program and the bachelor of arts program provide preparation for graduate school. Qualified students may be given permission at the end of the junior year to enter a program wherein they are able to begin work toward a graduate degree during the senior year. (See Combined B.A. or B.S. and M.S. program below.)

A minor in geological sciences is available for students who wish to combine an interest in earth science with technical or non-technical majors such as engineering, chemistry, mathematics, economics, management, government, international relations, English, journalism, and others.

Geological training is utilized in a variety of industries (especially in petroleum, mining, construction engineering, ceramics, and metallurgical industries), state and federal government service, natural resources management, and secondary school, college, and university teaching.

At the present time, career opportunities are particularly strong in the ground water industry, for work in contaminant mitigation, procurement of ground water supplies, and in ground water management.

A major in geophysics is offered in conjunction with faculty from cooperating departments. This program is described under “Geophysics”.

Major Requirements for B.S. in Geological Sciences
A minimum total of 122 credit hours is required.

college and university requirements (28 credit hours)

Engl 1  Composition and Literature (3)
Engl 2, 4, 6, 8, or 10  Composition and Film Study (3)
Arts & Science 1  Choices and Decisions
FS 90  College Seminar (3)
Dist. Elec.  (18 hours; 9 hrs. humanities, 9 hrs. social sciences)

Elective courses are nonprofessional courses designed to give the student a broad understanding in traditional and contemporary fields of thought outside of natural science and mathematics. The courses are chosen by the student.

major program (91-92 credit hours)

mathematics (12 credit hours)

Math 21  Analytic Geometry and Calculus I (4)
Math 22  Analytic Geometry & Calculus II (4)
Math 23  Analytic Geometry & Calculus III (4)

collateral sciences (21 credit hours)

Chm 21, 22  Introductory Chemistry Principles and Laboratory (5)
Chm 31  Chemical Equilibria in Aqueous Systems (3)
Phy 11, 12  Introductory Physics I and

Phy 21, 22  Laboratory (5)
CSC 11  Introduction to Structured Programming (3)
geological sciences (56-57 credit hours)

EES 21  Introduction of Earth Materials and Processes (4) or
EES 101  Geology for Engineers (3) or
EES 41  Physical Geology and Geomorphology in the Rocky Mountains (6)
EES 112  Geomorphology (3)
EES 113  Paleontologic Evidence for Earth Evolution: Life and Climate (3)
EES 122  Introduction to Plate Tectonics (3)
EES 131  Introduction to Rocks & Minerals (4)
EES 213  Sedimentology and Stratigraphy (3)
EES 223  Structural Geology (3)
EES 301  Introduction to Geophysics (3)
EES 326  Geologic Evolution of North America (3)
EES 334  Petrology of the Crust and Mantle (4)
EES 341  Field Geology (6)
EES 373  Geochemical Thermodynamics (3)

Note: EES 41 may be substituted for EES 21 and EES 112, or for EES 101 and EES 112. A student may not receive credit for both EES 41 and EES 21, or both EES 41 and EES 101, or both EES 41 and EES 112.

approved major electives (17 credit hours)

Courses approved to fulfill this requirement should form a coherent package supporting the professional objectives of the student. At least one professional elective, approved by the undergraduate advisors, must be a science, math or engineering course, taken outside of the Department of Earth and Environmental Sciences. Examples of coherent groups of courses that may serve to fulfill this requirement are as follows:

Emphasis on Surficial and Sedimentary Geology

EES 309  Environmental Magnetism (3)
EES 414  Glacial and Quaternary Geology (3)
EES 315  Soil Genesis (3)
EES 326  Evolution of North America (3)
EES 313  Depositional Environments and Facies Analysis (3)
EES 382  Statistical Applications (3)
EES 376  Geochemistry of Natural Waters (3)
CE 143  Soil Mechanics
### Emphasis on Tectonics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EES 302</td>
<td>Solid Earth Geophysics</td>
</tr>
<tr>
<td>EES 306</td>
<td>Geophysical Field Techniques (3)</td>
</tr>
<tr>
<td>EES 308</td>
<td>Seismic Data Analysis (3)</td>
</tr>
<tr>
<td>EES 313</td>
<td>Depositional Environments and Facies Analysis (3)</td>
</tr>
<tr>
<td>EES 326</td>
<td>Geologic Evolution of North America (3)</td>
</tr>
<tr>
<td>Math 205</td>
<td>Linear Methods (3)</td>
</tr>
</tbody>
</table>

### Emphasis on Hydrogeology

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EES 306</td>
<td>Geophysical Field Techniques (3)</td>
</tr>
<tr>
<td>EES 315</td>
<td>Soil Genesis (3)</td>
</tr>
<tr>
<td>EES 316</td>
<td>Hydrogeology (3)</td>
</tr>
<tr>
<td>EES 319</td>
<td>Evaluation and Management of Ground-Water Resources (3)</td>
</tr>
<tr>
<td>EES 313</td>
<td>Depositional Environments and Facies Analysis (3)</td>
</tr>
<tr>
<td>EES 382</td>
<td>Statistical Applications (3)</td>
</tr>
<tr>
<td>EES 376</td>
<td>Geochemistry of Natural Waters (3)</td>
</tr>
<tr>
<td>CE 381</td>
<td>Special Topics (1-3)</td>
</tr>
</tbody>
</table>

Other coherent groups of courses that meet the specific objectives of the individual student may be selected with the approval of an undergraduate faculty advisor.

### Recommended Sequence of Science Courses

#### freshman year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EES 21</td>
<td>Introduction to Earth Materials and Processes (4) or</td>
</tr>
<tr>
<td>EES 101</td>
<td>Geology for Engineers (3) or</td>
</tr>
<tr>
<td>EES 41</td>
<td>Physical Geology and Geomorphology in the Rocky Mountains (6) (summer preceding or following freshman year)</td>
</tr>
<tr>
<td>Math 21, 22</td>
<td>Analytic Geometry and Calculus I and II (8)</td>
</tr>
<tr>
<td>Chm 21, 22</td>
<td>Introductory Chemical Principles and Laboratory (5)</td>
</tr>
<tr>
<td>Phy 11, 12</td>
<td>Introductory Physics I and Laboratory (5)</td>
</tr>
</tbody>
</table>

#### sophomore year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EES 112</td>
<td>Geomorphology (3)</td>
</tr>
<tr>
<td>EES 113</td>
<td>Paleontologic Evidence for Earth Evolution: Life and Climate in the Rock Record (3)</td>
</tr>
<tr>
<td>EES 122</td>
<td>Introduction to Plate Tectonics (3)</td>
</tr>
<tr>
<td>EES 131</td>
<td>Introduction to Rocks &amp; Minerals (4)</td>
</tr>
<tr>
<td>Math 23</td>
<td>Analytic Geometry &amp; Calculus III (4)</td>
</tr>
<tr>
<td>Phy 21, 22</td>
<td>Introductory Physics II and Laboratory (5)</td>
</tr>
</tbody>
</table>

### B.A. in Geological Sciences

A minimum total of 121 credit hours is required.

#### college and university requirements (28 credit hours)

- Arts and Science 1, Choices and Decisions (1)
- English Composition (6)
- First Year Seminar (3)

Mathematic Sciences, requirement met in major program

#### Distribution requirements:

- Science (9), requirement met in major program
- Social Sciences (9)
- Humanities (9)

#### major program (63-66 credit hours)

##### mathematics (6-8 credits)

- Math 21, 22: Analytic Geometry and Calculus I, II (8) or
- Math 41, 44: BMSS Calculus I, II (6)

##### collateral sciences (14 credit hours)

- Chm 21, 22: Introductory Chemical Principles and Laboratory (5)
- Phy 11, 12: Introductory Physics I and Laboratory (5)
- EES 31, 32: Introduction to Environmental and Organismal Biology and Lab (4)

##### geological sciences (43-44 credit hours)

- Courses required of all majors (16-17 credit hours)
  - EES 21: Introduction to Earth Material and Processes (4) or
  - EES 101: Geology for Engineers (3) or
  - EES 41: Physical Geology and Geomorphology in the Rocky Mountains (6)
  - EES 131: Introduction to Rocks & Minerals (4)
  - EES 326: Geologic Evolution of North
Note: EES 41 may be substituted for EES 21 and EES 112, or for EES 10, and EES 112. A student may not receive credit for both EES 41 and EES 21, or both EES 41 and EES 101, or both EES 41 and EES 12.

One course to be selected from each of the three following categories (9-10 credit hours)

**Earth Structure and Tectonics**
- EES 122 Introduction to Plate Tectonics (3)
- EES 223 Structural Geology (3)
- EES 301 Introduction to Geophysics (3)

**Earth History and Surficial Processes**
- EES 112 Geomorphology (3)*
- EES 113 Paleontologic Evidence for Earth Evolution: Life and Climate in the Rock Record (3)
- EES 213 Sedimentology and Stratigraphy (3)
- EES 313 Depositional Environments and Facies Analysis (3)

*If EES 41 is taken, the equivalent of EES 112 is satisfied in this category.

**Earth Fluids and Materials**
- EES 316 Hydrogeology (3)
- EES 331 Economic Geology (3)
- EES 334 Petrology of the Crust and Mantle (4)
- EES 376 Geochemistry of Natural Waters (3)

**Electives in the major (18 credit hours)**
Approved courses in Earth and Environmental Sciences or related science that comprise a coherent program in an area of particular interest to the student. Students are particularly urged to undertake an undergraduate research project (EES 291) under faculty direction.

**free electives (minimum of 30 credit hours)**
Courses of the student's choice selected from Earth and Environmental Sciences or any other university curriculum. These courses may be used to build a minor in another curriculum such as education, law and legal institutions, chemistry, computer science, economics, English, government, journalism or science writing, international relations, etc.

**Recommended Sequence of Courses**

**Fall**
- EES 21 or 101 (3-4)
- Math 21 (4) or 41 (3)
- Physics 11, 12 (5)

**Spring**
- First year seminar (3)
- Chemistry 21, 22 (5)
- Math 22 (4) or 44 (3)

**sophomore year**
- EES 131 (3)
- EES 31, 32 (4)
- Free elective (6)
- Distrib. elective (3)

**junior year**
- EES category (3)
- Major elective (3)
- Free elective (3)

**senior year**
- EES category (3)
- Free elective (6)
- Major elective (3)

**Geology Minor (15-18 credit hours)**
A minor in geological sciences may be achieved by completing the following requirements.

- EES 21 Introduction to Earth Materials and Processes (4) or EES 101 Geology for Engineers (3) or EES 41 Physical and Historical Geology in the Rocky Mountains (6)
- EES 1221 Introduction to Plate Tectonics (3) or EES 113 Paleontologic Evidence for Earth Evolution: Life and Climate in the Rock Record (3)
- EES 131 Introduction to Rocks & Minerals (4)

and, any two Earth and Environmental Sciences courses at the 300-level or above (but not EES 101). (6)

**Combined B.A. or B.S. and M.S. Program in Geological Sciences**
The Department of Earth and Environmental Sciences offers a combined bachelor of arts or bachelor of science and master of science program in geological sciences. Students working toward the bachelor of arts or the bachelor of science in geological sciences who are enrolled in the program are permitted to take courses that apply toward the master of science degree during their senior year. During the student's senior year, the normal undergraduate tuition will cover the costs of all courses taken, including those that are taken for graduate credit.
After receiving the bachelor's degree, students registered in the program may acquire, if eligible for admission to The Graduate School, full-time graduate status, and, as such, they may apply for appointment to a teaching or research assistantship or graduate fellowship. The program is designed for those students who, upon completing the junior year and the field camp requirement, need less than thirty credit hours to complete work for the bachelor's degree. To be accepted into the program, students should have a superior record of academic performance.

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 faculty and the dean of Graduate Studies. The application must include: a tentative master of science program approved by the department's graduate coordinator, and a roster, also approved by the graduate coordinator, showing which courses taken during the senior year. All of the normal requirements for each degree as outlined must be fulfilled.

Students enrolled in this program should make application for admission to full-time graduate status after completing the first semester of the senior year.

Program in Civil Engineering and Geological Sciences

The Department of Earth and Environmental Sciences, in conjunction with the Department of Civil Engineering, administers a five-year program in geological engineering that leads to a bachelor of science degree in geological sciences. This is described under the heading of Civil Engineering and Geological Sciences in the catalog.

Departmental Honors in Earth and Environmental Sciences

Students in either the B.A. or B.S. curricula may undertake a program that leads to graduation with departmental honors. To participate, the student must have an overall cumulative GPA of 3.0 or greater, must file a written request with the undergraduate instruction committee for departmental honors during his/her junior year (or, at latest, at the beginning of the first semester of her/his senior year), and must complete at least 3 credits of earth and environmental research (EES 291). An advisory committee of 3 faculty is constituted to supervise and guide the research, and to approve the required honors thesis. In addition, students present their research results and conclusions orally in a departmental seminar.

Earth and Environmental Sciences

Undergraduate Courses

3. Global Environmental Change (3)

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.

11. Environmental Geology (3)

Analysis of the dynamic interaction of geologic processes and human activities. Catastrophic geologic processes, resource limitations and development, pollution of geologic systems, environmental legislation, engineering case studies. Evenson

21. Introduction to Earth Materials and Processes (4)

Introduction to the structure of the earth and processes of geologic change. Earth as a dynamic planet. Lecture, laboratory, and field trips. Meltzer, Myers

31. Introduction to Environmental/Organismal Biology (3)

Introduction to the structure, function, and evolution of living systems, with emphasis on the levels of organism, population, community, and ecosystem.

32. Laboratory Introduction to Environmental/Organismal Biology (1)


41. Physical Geology and Geomorphology in the Rocky Mountains (6) summer

Geology of Wyoming and Idaho. Six weeks of morning and evening lectures; afternoon field exercises. See EES 21 and EES 112 descriptions for course content. See EES 341 description for location details. Prerequisite: Consent of Field Camp Director Evenson.

90. College Seminar (3)

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

112. Geomorphology (3)

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 field trips. Prerequisite: EES 11, 21, or 101. Evenson
113. Paleontologic Evidence for Earth Evolution: Life and Climate in the Rock Record (3) spring
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

122. Introduction to Plate Tectonics (3)
Theory of plate tectonics with emphasis on plate geometry, geophysical relationships and geological consequences. Lectures and laboratory. Prerequisite: EES 21, or 101. Kodama and Zeitler

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

181. Introduction to Environmental Science (4)
Survey of interactions between life and earth systems, with emphasis on both modern systems and their evolution at geological time scales. Study of systems theory, major biogeochemical cycles, community and ecosystem dynamics, and climate and associated feedbacks. Lectures, laboratories, and computer exercises. Prerequisites: EES 31, 32 and EES 21 or EES 101 or EES 41. Staff

213. Sedimentology and Stratigraphy (3)
Processes of sediment transport, deposition, and diagenesis 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 departmental chairman. Carson

223. Structural Geology (3) fall
Application of basic concepts of stress, strain, and material properties to the study of folds, faults, fabrics, and other deformational structures in the earth's crust. Introduction to geometrical and field techniques. Lectures, laboratories and field trips. Prerequisites: An introductory geology course. Anastasio

251. Ecology (3)
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. Prerequisites: EES 31, 32. Williamson

252. Ecology Laboratory (1)
Laboratory and field trips related to ecological topics covered in EES 251. Prerequisite: EES 251, preferably concurrently.

291. Earth and Environmental Research (1-3)
Independent investigation of a special problem in the field laboratory, or library. May be repeated for credit up to a 12-credit maximum. Prerequisite: consent of chairperson.

Advanced Undergraduates and Graduate Students

301. Introduction to Geophysics (3)
Gravitational, magnetic, seismic, electrical, and thermal properties of the earth. Interpretation of field measurements to resolve crustal and near-surface earth structure. Lectures and laboratories. Prerequisites: One semester each of university calculus and physics. Kodama and Meltzer

302. Solid Earth Geophysics (3)
Study of rotation and figure of earth, global seismology and internal structure of the earth, heat flow and convection, geomagnetism, geodynamics, and planetology. Prerequisites: One semester each of university calculus and physics. Kodama and Meltzer

306. Geophysical Field Techniques (3)
Geophysical field investigation in an area of geological interest. Theory and application of seismic, gravity, magnetism, and electrical methods; data collection, interpretation, and written reports. Prerequisites: EES 301 or consent of department chairperson. Kodama

307. Case Histories in Engineering Geology (3)
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. Prerequisites: Open to all majors in the Department of Earth and Environmental Sciences, Civil Engineering, or students who have successfully completed 6 credit hours of Earth and Environmental Science at or above the 100 level, excluding EES 101. Myers

308. Seismic Data Analysis (3)
The use of seismic reflection data to determine earth structure and properties. Course emphasizes seismic experiment design, data processing techniques, and interpretation procedures. Students are expected to complete a seismic data processing and interpretation project including the integration of surface and subsurface geologic data. Prerequisites: EES 301 or permission of the instructor. Meltzer

309. Environmental Magnetism (3)
The use of earth material magnetic properties to study environmental systems. Specific examples include: Determining the flux and source of lake and marine sediments. Techniques of magnetic measurements,
characteristics of the Earth's magnetic field, and mineral magnetism will also be discussed. Prerequisites: EES 21, or EES 101. Kodama

313. Depositional Environments and Facies Analysis (3)
Interpretation of sedimentary records on the basis of sedimentary rock composition and structures; characteristics of continental, continental margin, and marine deposits; facies as indicators of source, depositional environment, and tectonic setting; principles of basin analysis and sequence stratigraphy. Lectures, laboratories, and field trips. Prerequisites: EES 113, EES 131, and EES 213. Carson.

315. Soil Genesis (3)
Genesis, classification and application of pedology. Weathering of parent materials; chemistry of soils; geologic, biologic, and climatic controls on soil formation; application to geologic and engineering concepts. Lecturers and two all-day field trips. Prerequisite: EES 213 or consent of the department chairperson. Evenson, Myers

316. Hydrogeology (3)
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. Prerequisites: EES 21, or 101. Myers

319. Environmental Applications of Geographic Information Systems (3)
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

324. Structural Analysis (3)
Field methods emphasizing interpretation of minor structures and practical application of geologic strain and petrofabric analysis applied to regional geologic problems. Seminars, laboratories, and field trips. Prerequisites: EES 223. Anastasio

326. Geologic Evolution of North America (3)
A senior seminar on the lithologic, tectonic, and morphologic evolution of North America; developed within the framework of the plate tectonic theory. Anastasio and Myers

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

337. X-ray Diffraction of Materials (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. Prerequisite: consent of department chairperson.

338. 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 chairperson.

341. Field Geology (6) summer
Field study and geologic mapping of sedimentary, igneous, metamorphic, and glacial deposits in the Rocky Mountains of northwestern Wyoming, and southeastern Idaho. Additional short studies 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 the department chairperson. Graduate credit not given for this course. Evenson, Myers, Anastasio

351. Limnology (3)
Physical, chemical and biological aspects of freshwater environment, including cyclic and seasonal changes. Major groups of organisms and their interactions. Prerequisites: EES 31, 32.

352. Aquatic Ecology Laboratory (1)
Field-oriented investigations of the physical, chemical, and biological characteristics of lakes and streams related to topics covered in EES 351.

353. Environmental Microbiology (3)
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

361. Animal Physiology (3)
Structure and function of animals at the level of tissues, organs, organ systems, and whole organisms interacting with
the environment. Prerequisite: EES 31, 32 and at least one semester each of physics and chemistry. Hargreaves

362. Animal Physiology Laboratory (1)
Laboratory investigation of structure and function of organs and intact animals, in relation to topics covered in EES 361. Prerequisite: EES 361, preferably concurrently. Hargreaves

373. Geochemical Thermodynamics (3)
Macroscopic chemical thermodynamics with applications to geochemical processes. Thermodynamic relationships, geochemical equilibria, and an introduction to kinetics. Prerequisites: EES 133 and Chm 31. Moses

375. Water-Rock Interaction Seminar (1)
Discussions of current and "classic" literature in water-rock interactions, selected and presented by participants. Brief writing exercises. Prerequisite: EES 171 and consent of instructor. Moses

376. Geochemistry of Natural Waters (3)
Introduction to aqueous geochemistry. Applications of: thermodynamics, mass balance, system analysis, kinetics to understanding water-rock interactions and biogeochemical cycles. Laboratories emphasize computations and geochemometrics. Prerequisites: two semesters of chemistry, two semesters of calculus, and EES 131. Moses

381. Senior Seminar in Environmental Science (3)
Advanced examination and discussion of current issues in environmental science. Work will include readings from the technical literature, student presentations and reports, and some combination of field, laboratory, and computer projects. Course enrollment limited to senior majors in environmental science. Staff

382. Statistical Applications in Earth and Environmental Sciences (3)
Univariate and bivariate statistical models with specific reference to geological, hydrological, and biological field and laboratory studies. Analysis of variance, applications of the Chi-square distribution, analysis of covariance, linear, nonlinear and multiple regression, and distribution-free methods. Carson

383. Environmental Data: Acquisition, Analysis, and Management (3)
Acquisition, analysis and management of environmental datasets with emphasis on aquatic ecosystems and electronic tools. Data from a variety of computer-controlled and programmable field instruments, and from existing databases available through computer networks. Lectures and laboratories. Prerequisites: EES 181, CSc 11 or other introduction to computer programming, and departmental approval. Hargreaves.

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 3 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.

For Graduate Students
The Department of Earth and Environmental Sciences offers graduate degree programs leading to the MS or PhD 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, isotope 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, glacial and Quaternary geology, environmental physiology, environmental magnetism, microbial ecology, aqueous geochemistry, and plankton ecology. Three course programs are available, providing concentrations in Environmental Biology or Surface 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: Phillips 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; belt-type ultra-high-pressure apparatus for upper mantle studies; 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 Bisone DIFP multi-channel x seismograph; sedimentation laboratory equipped with Particle Data computer-based particle-size analyzer and rapid sediment analyzer; field geophysical equipment including Bisons shallow refraction seismic unit and Bisons shallow resistivity apparatus, master Wordon gravimeter, Geometrics portable proton precession magnetometer; Keck borehole logging equipment including caliper, natural gamma, electrical resistivity, and self-potential probes; downhole geochemical sampling equipment; Waters computer-assisted ion chromatograph; ARL 34000 inductively-coupled plasma atomic emission spectrometer; NETZSCH DTA/tga analyzer; Sun and IBM workstations which support CADD, 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 backsattered 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 aqueous environments. The department also has the Pocono Comparative Lakes Program (PCLP), 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 PCLP, please contact Prof. Williamson (610-758-3660).

405. Paleomagnetism (3)
Characteristics and history of the earth’s magnetic field, rock magnetism, field and laboratory techniques, statistical analysis of paleomagnetic data, tectonic and geochronologic applications of paleomagnetism. Prerequisite: Phys 21. Kodama

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. Meltzer

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. Evenson

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

417. Advanced Glacial Geology (3)
Seminars on advanced topics in glacial geology; review of classic and contemporary literature. Topics include dynamics of glacier movement, glacial landforms and deposits, glacial stratigraphy. Field trips. Prerequisite: EES 414 or consent of the department chairperson. Evenson
418. Advanced Geomorphology (3)
Lectures and seminars on advanced topics in geomorphology. Field trips. Prerequisite: EES 112 or consent of the department chairperson. Evenson

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

427. Thrust Belts (3)
Geometry and mechanics of thrust belts and structural tools necessary to study orogenesis. Topics include thrust and normal faults, folds, minor structures, basement-cover problems, the plutonic and metamorphic hinterland, and foreland basins. Structures are placed in regional context: Andes, Appalachians, Caledonides, Himalayas, North America Cordillera, Pyrenees, or Western Alps. Lectures and field trips, including one long one. Prerequisite: EES 223 or equivalent. Anastasio

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 223 or equivalent. Anastasio

429. Applications of Geochronological Methods (3)
Advanced seminar on the application of geochronological methods to problems in tectonics, stratigraphy, and climate change. Topics include thermochronology and diffusion systematics in radiogenic systems, precise dating of stratigraphic sections, calibration of dating schemes, and geochronology of very young Earth materials. May include laboratory, field and computer exercises. May be repeated for credit as the topic varies. Prerequisite: consent of instructor. Zeitzer

434. Advanced Topics in Petrology and Geochemistry (1-6)
Discussions of current topics in igneous and metamorphic petrology and crust-mantle geochemistry. Bebout and Myers

438. Advanced Metamorphic Petrology (3)
Processes involved in the transformation of rock masses at high temperatures and pressures. Tectonic evolution, crust-mantle heat and mass transfer, fluid-rock interactions, kinetics of recrystallization. Topics will vary somewhat with interests of students. Lectures, seminars, laboratory sessions, field trip(s). Prerequisite: EES 334 or equivalent or consent of instructor. Bebout

451. Advanced Ecology (3)
Seminars, conferences and 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

452. Community Ecology (3)
Current concepts in the ecology of animal communities. Theoretical and experimental approaches to understanding the primary factors which regulate the structure and dynamics of communities. Prerequisite: EES 251 or equivalent. Williamson

461. Comparative Animal Physiology (3)
Lectures and seminars on selected areas in the comparative physiology of animals. Introduction to the current literature of subjects studies. These include mechanisms of osmotic control, temperature effects, nerve and muscle physiology and others. Prerequisite: EES 361. Hargreaves

471. Stable Isotope Chemistry - Theory, Techniques, and Applications in the Earth and Environmental Sciences (3)
Distributions of stable isotopes (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

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

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

490. Thesis Research (1-6)
Masters' thesis research directed by research committee. 3-6 credits required for EES MS programs. May be repeated for credit. Prerequisite: Permission of research adviser.

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.
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.

493. Advanced Topics in Tectonics (1-6)
Intensive study of tectonic processes and products not covered in more general courses.

494. Advanced Topics in Aquatic Ecosystems (1-6)
Intensive study of aquatic ecosystems not covered in more general courses.

499. Dissertation research (1-15)
PhD dissertation research directed by research committee. May be repeated for credit. Prerequisite: Permission of research advisor.

Economics

Professors: J. Richard Aronson, Ph.D. (Clark); Clayton Professor; Alvin Cohen, Ph.D. (Florida); Thomas J. Hyclak, Ph.D. (Notre Dame); Jon T. Innes, Ph.D. (Oregon); Arthur E. King, Ph.D. (Ohio State); William R. McNamara, Ph.D. (Rensselaer); Vincent G. Munnley, Ph.D. (S.U.N.Y., chairman; Robert J. Thornton, Ph.D. (Illinois), MacFarlane Professor.

Associate professors. Colleen M. Callahan, Ph.D. (North Carolina), major advisor and curriculum director; James Dearden, Ph.D. (Penn State); Mary Deily, Ph.D. (Harvard); Frank R. Gunter, Ph.D. (Johns Hopkins); Anthony P. O'Brien, Ph.D. (Berkeley); Larry W. Taylor, Ph.D. (North Carolina).

Assistant professors. Darlene Chisholm, Ph.D. (Washington); Judith McDonald, Ph.D. (Princeton); Todd Watkins, Ph.D., (Harvard).

Active emeriti. Nicholas W. Balabkins, Ph.D. (Rutgers); John A. Pilisbury, Ph.D. (Virginia); 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 Science 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 their major in government, 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. The requirements for the major and minor programs listed below pertain to the graduating classes of 1996 and later.

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 as listed in the College of Business and Economics section of this catalog. They must also take Econ 119 and at least 12 credit hours of 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. Colleen Callahan) in forming their programs.

Major in College of Arts and Science

Required Courses (30 credits)
Econ 11, 12 Principles of Microeconomics (3) and Principles of Macroeconomics (3)
Math 41, 44* BMSS Calculus I and II (6)
Acct 151** Introduction to Financial Accounting (3)
Eco 105 Intermediate Microeconomic Analysis (3)
Eco 119 Intermediate Macroeconomic Analysis (3)
Eco 145 Statistical Methods (3)
Eco 229 Money and Banking (3)
Fin 225** Business Finance (3)

* Students who wish to take mathematics beyond calculus or are considering graduate work in economics should substitute Math 21, 22, and 23 for this requirement.
** Management I (Introduction to Business Computing) is helpful background for Acct 151 and Fin 225.
Elective Courses (12 credits)
Students must take 12 credit hours of 300 level economics courses beyond the requirements listed above. One upper-level finance course may be substituted for an economics course with the approval of the major advisor.

Minor in Economics
A minor in economics consists of 12 credit hours beyond Economics 11 and 12. Required courses in the minor are: Economics 105 or 115, 119 or 229, and two elective courses. Elective courses must be chosen from among the 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 In Economics
1. Economics (4)
A one-semester course in the principles of economics. General topics covered are: the determination of national income; the determination of relative prices; money and banking; monetary and fiscal policy; and government finance. (Not available for credit to students who have taken Eco 11 or 12.)

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.)

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.)

101. (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. Prerequisites: Eco 1, or Eco 11 and 12.

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. Prerequisites: Eco 1 or Eco 11. (Not available for credit to students who have taken Eco 115.)

115. Applied Microeconomic Analysis (3)
The application of economic analysis to managerial and public policy decision making. Prerequisites: Eco 1 or Eco 11. (Not available for credit to students who have taken Eco 105.)

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. Prerequisites: Eco 1 or Eco 12.

132. (Gov't 132, Hist. 132, and I.R. 132) An Introduction to Canada (3)
An interdisciplinary, team-taught course focusing on history, politics, economics and international relations. Topics covered include Canada's historical development, recent politics and foreign policy, and economic trade issues. Special attention will be given to contemporary affairs and to Canada's relations with the United States.

145. Statistical Methods (3)
Descriptive statistics, probability and probability distributions, sampling, estimation, hypothesis testing, regression and correlation, analysis of variance, nonparametric tests, and index numbers.

For Advanced Undergraduates And Graduate Students
229. Money and Banking (3)
A course dealing with the nature and functions of money, money markets, and commercial and central banking. Effects of the interest rate and money supply on economic activity. Examination and evaluation of current and past monetary policies. Prerequisites: Eco 1, or Eco 11 and 12.

303. Economic Development (3)
The principal determinants of economic development theories are examined. Most of the theories are applicable to both the advanced industrial societies and to the poorer nations, but the emphasis is on the developmental process of the countries of the Third World. Prerequisites: Eco 1, or Eco 11 and 12.

Cohen

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. Theories are presented along with their application via the examination of country case studies. Prerequisites: Eco 1, or Eco 11 and 12.

Cohen

309. 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. Prerequisites: Eco 1,
or Eco 11 and 12. King

310. Economic Evolution (3)
Structural changes, social transformation, and sources of the long-term growth of the U.S. economy. Prerequisites: Eco 1, or Eco 11 and 12. O'Brien

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

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. Prerequisites: Eco 1, or Eco 11 and 12. Hyclak

313. History of Economic Thought (3)
Study of the evolution of economic science. Critical analysis of the contributions of major economists from the 18th through the 20th centuries. Prerequisites: Eco 1, or Eco 11 and 12. Cohen

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

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

331. 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. Prerequisites: Eco 1, or Eco 11 and 12 (Eco 145 is recommended). O'Brien

332. (Fin 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 229. Innes

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 and 145 and Math 41 and 44 (or equivalents) or consent of instructor. McNamara

334. 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. Prerequisites: Eco 1, or Eco 11 and 12. Hyclak

335. 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. Prerequisites: Eco 1, or Eco 11 and 12. Thornton

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. Delly

337. Transportation Economics (3)

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. Prerequisites: Eco 1 or Eco 11. McDonald

340. (Fin 340) International Finance (3)
Analysis of balance of payments and disturbances and adjustment in the international economy; international monetary policies. Prerequisite: Eco 229. Callahan

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. Prerequisites: Eco 1, or Eco 11 and 12. King

346. Business Cycles and Forecasting (3)
A study of short-term business fluctuations, growth, forecasting and stabilization. Prerequisites: Eco 1, or Eco 11 and 12, and a course in statistics.

351. Introduction to Mathematical Economics (3)
Application of mathematical techniques to economic
problems of optimization and to economic models.
Prerequisites: Math 41 and 44, Eco 105 or 115 and 119.
Chisholm

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 1, or Eco 11 and 12, and a course in statistics. Taylor

353. (Fin 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. Prerequisites: Eco 1 or Eco 11 and 12. Aronson

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. Prerequisites: Eco 1 or Eco 11 and 12. Aronson, Munley

357. Econometrics (3)
Problems in construction, evaluation and use of econometric models. Applications based on research and case studies. Prerequisite: a course in statistics and a course in intermediate economic theory. Prerequisites: Eco 1 or Eco 11 and 12. Aronson

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: Math 41 and Eco 105 or 115. Dearden

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.

362. Martindale Research Seminar (1-3 hrs.)
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.

363. Lehigh in Guatemala (3)
This course is offered to students participating in the "Lehigh in Guatemala" program. It combines guest lectures, supplemental reading materials, visits to Indian villages, to sites of historical importance, and to commercial and industrial enterprises with writing exercises. Prerequisites: Eco 11 and 12. Does not count toward graduation requirements for economics majors. Cohen

368. Health Economics (2)
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

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 chairman.

372. Special Topics in Economics (1-3)
Continuation of Eco 371.

For Graduate Students

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.

408. Price Theory and Applications (3)
The role of the price mechanism in the allocation of resources. Theoretical development and empirical estimation of demand, production and cost functions. Analysis of equilibrium price-output determination in competitive and monopolistic markets. Prerequisites: Eco/Mgt 101 (or calculus) and Eco 401 (or equivalent).

409. Money, Banking, and Macroeconomic 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. Prerequisite: Eco 408 (or concurrently).

411. Energy Economics (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: Eco 408 and Mgt 401 or equivalents. McNamara

413. Urban Economics (3)
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.

415. Econometrics I (3)
Computer applications of standard econometric techniques using regression analysis in a single equation context. Discussion of problems of multicollinearity, heteroscedasticity and autocorrelation. An introduction to simultaneous equation models, identification and estimation problems. Prerequisite: a course in basic statistics. King

419. Economic History of the United States (3)
Analysis of the colonial economy, transition to industrialization, and role of trade and transportation in America's development. A consideration of the importance of slavery to the 19th century American and other New World economies. Origin and development of banking and financial markets. Prerequisites: intermediate microeconomic theory and basic statistics. O'Brien

420. Advanced Macroeconomic Analysis (3)
Macroeconomic theory and policy. Primary emphasis on theoretical models and policy implications. Prerequisite: Eco 119 or equivalent. Innes

421. Managerial Economics (3)
Application of economic analysis to business problems: price and output determination in various markets, analysis of cost and the forecasting of business conditions. Case studies. Prerequisites: Eco/Mgt 101 (or calculus) and Mgt 401 (or equivalent) and course in intermediate microeconomic theory. McNamara

432. Advanced Microeconomic Analysis (3)
A survey of methods of decision-making at the microeconomic level; price theory and econometric applications. Prerequisite: Eco 408 or equivalent. Dearden

433. (Fin 433) Valuation Seminar (3)
Determinants of financial asset values. The role of uncertainty, imprecise forecasts, risk preferences, inflation, and market conditions. Prerequisite: Fin 411. Beideman, Buell

434. Government Regulation of Business (3)
Analysis of the economic justification for government regulation of private enterprise. Topics include antitrust policy, utilities, and health, safety and environmental regulation. Prerequisite: a course in intermediate microeconomic theory. Deily

435. Advanced Topics in Microeconomics (3)
Resource allocation and price determination. Theories of choice of consumers, firms and resource owners under various market forms. Prerequisite: Eco 432 and 145 or equivalents. Dearden

436. Advanced Topics in Macroeconomics (3)
Models of employment, income, and growth in monetary economies. Policies for economic stability and growth. Prerequisite: Eco 420 or equivalent. O'Brien

437. Labor Economics (3)
The economics of labor markets and various labor market institutions with emphasis on current theoretical and empirical research. Prerequisites: Eco 408 and 401 or equivalents. Thornton

438. 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. Hyclak

439. 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. Schwartz

440. Regional Science-Metropolitan Analysis (3)
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.

443. Economics of Environmental Management (3)
The effect of environmental policies on resource allocation. Survey of the major pollution control programs currently in place in the U.S. Prerequisite: Eco 408. Munley

444. (Fin 444) Banking and Monetary Policy (3)
Analysis of the U.S. monetary and banking systems. Financial markets. Central bank controls, monetary theory and policy. Prerequisite: a course in money and banking. Innes, Schwartz

445. International Trade Theory (3)
Theories of comparative advantage, factor price equalization, trade and welfare, tariffs, trade and factor movements. Prerequisite: Eco 432 or consent of the chairman. Gunter

446. International Monetary Economics (3)
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: Eco 420 or consent of the chairman. McDonald

447. (Fin 447) 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: a course in
449. (Fin 449) 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. Aronson, Munley

451. International Economic Development (3)
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. Cohen

453. Index Numbers and Time Series Analysis (3)
Classical decomposition of time series, trend analysis,
exponential smoothing, spectral analysis and Box-Jenkins
autoregressive and moving average methods. Taylor

454. Forecasting (3)
Methods of economic and business forecasting. Taylor

455. Econometrics II (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: Eco 415, 445 and 456 or equivalent
background in statistics, calculus and matrix algebra. Taylor

456. Mathematical Economics (3)
Applications of various mathematical techniques in the
formulation and development of economic concepts and
theories. Prerequisite: consent of the department chairman.
Chisholm

457. (Fin 457) 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: Eco/Fin
444 or equivalent. Gunter

458. Topics in Game Theory (3)
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, Eco 435 and Eco 456 (or permission of the
instructor). Dearden

459. (Fin 459) International Financial Economics (3)
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. Gunter

461. Methodology in Theory and Research (3)
Foundations of theory construction and empirical research in
economics.

463. Advanced Statistics for Business and Economics (3)
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.
Prerequisites: Math 41 and Math 44 or equivalents. Taylor

465. Industrial Organization (3)
Theoretical and empirical analysis of how the structure,
organization, and behavior of firms and industries affect
economic performance and economic welfare. Prerequisite:
Eco 408 or equivalent. Chisholm

467. Economics of Technical Change (3)
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; and evaluation of the
justifications for government support of R&D. Prerequisites:
Eco 408.

468. Health Economics (3)
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. Prerequisites: Eco 401
and Eco 408, or permission of the instructor. King

471. Special Topics in Economics (1-3)
Extended study of an approved topic not covered in scheduled
courses.

472. Special Topics in Economics (1-3)
Continuation of Eco 471.

490. Thesis

499. Dissertation in Economics and Business
Education, College of

Alden J. Moe, dean.

The College of Education has one academic department, the Department of Education and Human Services. The department faculty and program offerings are listed below followed by descriptions of course offerings. More details on specific degree requirements and on University Graduate School regulations can be found in the section on Advanced Study and Research.

Department of Education and Human Services
Professors. Raymond Bell, Ed.D. (Lehigh); chairperson; Diane M. Browder, Ph.D. (Virginia); Donald T. Campbell, Ph.D. (California Berkeley); Joseph P. Kender, Ed.D. (Pennsylvania); J. Gary Lutz, Ed.D. (Lehigh); Edward S. Shapiro, Ph.D. (Pittsburgh); Arnold R. Spokane, Ph.D. (Ohio State); LeRoy J. Tuscher, Ph.D. (Florida State); Perry A. Zirkel, J.D. Ph.D. (Connecticut), LL.M. (Yale), University Professor of Education and Law.


Assistant professors. Asha K. Jitendra, Ph.D. (Oregon); Richard P. McAdams, Ed.D. (Temple); April E. Metzler, Ph.D. (Florida); Tina Q. Richardson, Ph.D. (Maryland); Gail G. Smith, Ed.D. (Pennsylvania State).

Adjunct faculty. Christina Le Ager, Ph.D. (Lehigh); Deborah Barlieb, Ph.D. (Penn State); Eileen Bauer, Ph.D. (Lehigh); Tori Bronaugh, Ph.D. (City Univ. of NY); Patricia Budd, Ph.D. (Lehigh); Herman Corradetti, Ph.D. (Univ. of Rome, Italy); Leigh Cundari, Ed.D. (Lehigh); Priscilla D'Aniabile, M.S. (Lehigh); Kimberly Ewing, Ph.D. (Ohio State); Paula A. Fantaski, Ph.D. (Pittsburgh); Diane E. Flisser, Ed.D. (Lehigh); Scott Garrigan, Ed.D. (Lehigh); Scott C. Greenwood, Ed.D. (Lehigh); Robert L. Leight, Ed.D. (Lehigh); Levan Lim, M.Ed. (Texas); Michael McAllister, Ph.D. (Oregon); John D. McAndrew, Ed.D. (Lehigh); Barry McCurdy, Ph.D. (Lehigh); Ann Minutti, Ph.D. (Wayne State); James E. Morell, Ed.D. (Lehigh); Joanne Regina, Ph.D. (Detroit); Herbert Rubenstein, Ph.D. (Columbia); Bruce S. Sharkin, Ph.D. (Maryland); Stephanie Skumanich, Ph.D. (Lehigh); David R. Snyder, Ed.D. (Lehigh); Diane Toby, Ph.D. (Pennsylvania State).

The department offers master's degrees and/or professional certification in Bilingual/Bicultural Education, Counseling and Human Services, Educational Technology, Educational Leadership, Elementary and Secondary Education, Reading, School Counseling, Special Education and Social Restoration 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, Elementary Education, and Reading. 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 320. (Psyc 320) Psychology of Language (3)
Study of the experimental and observational literature on psychological processes involved in the production, comprehension and use of language by adults.

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 330. Study of the Individual (3-6)
Examinations of individual growth and development, especially the patterns found in different subcultures. Prerequisite: consent of the program director.

Educ 341. The Teacher in Social Restoration (3-6)
Functions of the teacher and the school in prevention and remediation of antisocial behavior. Field work in remedial teaching and experience in social restoration institutions. For social restoration interns only.

Educ 343. The Disadvantaged Student (3)
Philosophical analyses of disadvantagement and relevant educational theories. Applications and evaluations of special methods and techniques.

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 400. Educational Psychology (3)
An overview of learning theories, human growth and development, and the effect of selected educational practices upon the student. Attention is given to alternative strategies and processes of learning intervention.

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 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 SchP/SpEd 405.

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)
Social science research methods for non laboratory settings. Detailed examination of a dozen quasi-experimental research designs, three dozen threats to validity, possible controls, and uses in social program evaluation. Nonmathematical presentation.

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 notation, experience with numbers, operations with numbers, number concepts and numerals, and elements of geometry.

Educ 420. Linguistics in Education (3)
The nature of language, phonetic applications and the relationships of linguistics to instruction in the language arts.

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 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 daily realities of growing up bilingual in our society. Emphasis is placed upon a nondeficit philosophy, exploring the strengths and unique contributions of bilingual families in the cognitive and social development of children.

**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 455. Philosophical and Historical Foundations of Curriculum Study (3)**
Analysis of the philosophical, historical, sociological, and psychological foundations of curriculum study. Particular emphasis upon key historical figures, policy statements and major movements in the curriculum field.

**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 Ns. Topics include design theory and application, experimental validity (internal,
external, statistical conclusions and construct validity) and an overview of data analysis procedures.

Educ 471. (CPsy 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 474. (Psyc 474) Psychological Development in Childhood (3)
Topics selected from such areas as socialization and the parent-child interaction, personality disorders in childhood, moral development and cognitive development. 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 schools. 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.

Educational Leadership

For Graduate Students

EdL 400. Educational Administration: 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 406. School Principals Clinic (3-6)
Simulated materials workshop on administrative decisionmaking open to practicing and prospective elementary and secondary school administrators.

EdL 411. 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 Administration.

EdL 412. Computer Applications in School Administration (3)
Hands-on experience with computer applications useful in the administration of schools. Applications will include work processing, data base management, financial and demographic forecasting, resource allocation, graphical representation of data, and data retrieval and reporting systems useful for administrative decision making.

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 467. Management Seminar for Supervisors (3)
A seminar on organization and management for first-line instructional supervisors. Covers four areas, including the legal aspects of supervision, budget development, evaluation, and organization behavior.

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 (1-6)**
Intensive study and discussion of a specialized area. Title will vary. May be repeated for credit as title varies.

**EdL 472. 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 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 474. Planning for Facility Use (3)**
Focus on long-range planning with emphasis on data collection and analysis involved in closing, modifying and/or establishing alternative uses for school facilities. Simulations and field applications are provided.

**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.

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**Counseling Psychology**

**CPsy 427. (SchP 427) Standardized Tests and Measurements (3)**
Principles of psychological measurements utilizing assessment techniques with focus upon standard group and individual tests. Administration and interpretation of tests.

**CPsy 430. Philosophy and Principles of Counseling (3)**
Theoretical foundations, principles, and legal and ethical aspects of counseling. The organization, function, and services of a counseling program are examined. Accountability, counseling the culturally different, use of standardized tests, and other current issues are considered.

**CPsy 433. Community Psychology (3)**
Community agencies are examined through readings, lectures and student presentations. Field investigation of a community counseling agency. Professional ethics, legal issues, accountability and organizational structure of agencies.

**CPsy 436. Career Development (3)**
Examination of the career development process for children, adolescents, and adults. Study of theorists, vocational assessment process, and occupational and psychological information systems.

**CPsy 439. Theory and Practice of Group Counseling (3)**
Introduction to the process of group counseling and therapy. Selection of group members; group rules; group procedures with children, adolescents and adults; ethical considerations with groups. Study of research on group processes, group therapy, and group leadership. Prerequisites: permission of the program coordinator required.

**CPsy 440. Introduction to Family Counseling (3)**
Research and current trends in the practice of family counseling. Overview and analysis of major theoretical approaches of family therapy.

**CPsy 442. Counseling and Therapeutic Approaches (3)**
Introduction to theories and techniques of counseling and therapy. Students will practice therapeutic skills through role play and sessions with clients. Audio and video recordings required. Prerequisites: CPsy 430 or CPsy 433 or permission of instructor.

**CPsy 445. Elementary School Counseling and Guidance (3)**
Emphasizes professional concerns of the elementary school counselor in working with teachers, parents, administrators, and other specialists. Policies, practices, and curriculum concerns, as they affect the development of the child. Prerequisite: CPsy 430.
CPsy 448. Secondary School Counseling and Guidance (3)
Establishing an effective secondary counseling and guidance program within the framework of the school setting. Policies, procedures, and curriculum concerns as they affect the student. Professional approaches to involve students, teachers, administrators, and parents in the counseling and guidance activities of the secondary school. Prerequisite: CPsy 430.

CPsy 451. Group Counseling and Group Processes (3)
Group processes as related to counseling and psychotherapy through group participation and demonstration. Prerequisites: CPsy 442 previously or concurrently; CPsy 439; permission of the program coordinator required.

CPsy 454. Stress Management (3)
Theory and background in health psychology and the social and physiological substrata of stress. Practice in stress management techniques. Experience using biofeedback and cognitive control and other counseling and developmentally oriented strategies for promoting healthy lifestyles and preventing negative effects of stress. Special attention paid to relaxation procedures, anxiety management, and behavioral medicine. Prerequisite: CPsy 442.

CPsy 457. (Psyc 473) 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.

CPsy 460. (Psyc 475) 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 problems. Prerequisites: admission to the Ph.D. program in counseling psychology, or permission of the counseling psychology program coordinator.

CPsy 461. Assessment of Adult Intellectual Functioning (3)
Administration and interpretation of individual tests/ batteries of adult intelligence and neuropsychological functioning. Consideration of psychological and crosscultural issues in intellectual assessment. Preparation of psychological reports. Prerequisite: CPsy 427, and permission of the instructor.

CPsy 462. Assessment of Personality (3)
Consideration of issues and methods of personality assessment, including ethical and legal issues, and crosscultural 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 463. Professional and Ethical Issues in Counseling Psychology (3)
History and overview of the field of Counseling Psychology. Ethical and legal issues, including APA ethical principles, confidentiality and privilege, licensing, professional relationships, multicultural issues, teaching, research, and supervision.

CPsy 466. 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 470. 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. Research Seminar in Counseling (1-3)
For doctoral students in counseling psychology. Issues and methods in research design, data collection, and data analysis, criticism and evaluation of student proposals. Admission to the Ph.D. program in counseling psychology or permission of the counseling psychology program coordinator.

CPsy 474. Pre-Practicum I (3)
Beginning counseling skills are taught using audio and video recordings. Supervision is provided in small groups. Prerequisite: permission of instructor.

CPsy 475. Pre-Practicum II (3)
Counseling skills and key concepts are taught using audio and video recordings. Supervised experience in a counseling setting. Prerequisite: CPsy 474.

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 478. Advanced Group Leadership (1-6)  
Practicum training in group leadership in a counseling or therapeutic setting. Prerequisites: CPsy 439, CPsy 451, 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 442, CPsy 451, CPsy 475, and permission of instructor. May be repeated for credit.

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 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 Practicum I (3)  
Supervised clinical experience for entry-level doctoral students. Emphasis on intake and assessment procedures. Audio and video recording, staffing, and individual and group supervision. Prerequisite: admission to the Ph.D. program in counseling psychology, and permission of the counseling psychology program coordinator.

CPsy 488. Advanced Practicum II (3)  
Supervised clinical experience with emphasis on the development of intervention skills. Audio and video recording, staffing, and case presentations are required. Individual and group supervision. Prerequisite: CPsy 487. Admission to the Ph.D. program in counseling psychology and permission of the counseling psychology program coordinator.

CPsy 489. Advanced Practicum III (3)  
Supervised experience in counseling and therapeutic settings for doctoral students. Use of audio and video recordings, small group supervision, and individual supervision, case presentations required. Prerequisites: CPsy 488, admission to the Ph.D. program in counseling psychology, and permission of the counseling psychology program coordinator.

CPsy 491. Advanced Practicum IV (3)  
Supervised experience in counseling and therapeutic settings for doctoral students. Use of audio and video recordings with emphasis on a blend of individual and group counseling, consultation, training and supervision. Case presentations, small group supervision and individual supervision are required. Prerequisites: CPsy 489 and permission of the counseling psychology program 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 Technology  
EdT 311. Instructional Programming in BASIC (3)  
Introduction to microcomputers and their applications in educational settings. Special emphasis on a structured approach to programming in the BASIC language and on application of principles of instructional design to the development of microcomputer-based instructional materials. No prior experience with microcomputers or programming is assumed. Departmental approval required.

EdT 313. Instructional Programming in PASCAL (3)  
PASCAL for microcomputers. High level, structured, procedure-oriented languages are examined. Special emphasis on use of structured programming for designing instructional software. Students electing EdT 313 are expected to complete the same course requirements as students taking CSc 11. In addition, they are required to become familiar with a microcomputer disk operating system. This is achieved through course assignments requiring the use of a microcomputer. The additional course requirements add an extra hour per week to the student workload.

EdT 315. Elementary Artificial Intelligence Applications (3)  
How computers play chess, compose music, create prose, simulate psychiatrists, and make medical diagnosis (an illustration of expert systems).

EdT 331. Human Information Processing (3)  
Study of the processes involved in perception, learning, problem solving and decision making. Applications of task analysis and artificial intelligence to the design of learning system.

EdT 351. Cognitive Science (3)  
A synthesis of elements of artificial intelligence, psychology and linguistics; concerned with models of the acquisition, representation, storage, retrieval and application of knowledge.
EdT 404. Interactive Multimedia Programming (3)
Introduction to programming interactive multimedia applications in education and training. Emphasis given to event driven, object-oriented like programming in the design and creation of applications utilizing sound, video, graphics and computer animation.

EdT 405. Hypermedia Theory and Applications (3)
Analysis of the theory of hypertext and hypermedia. Emphasis on the examination of current practices and research in hypermedia. This course is a complementary course to courses on hypermedia programming.

EdT 406. Advanced Multimedia Design and Programming (3)
Application of advanced hypermedia programming techniques utilized in the design and delivery of microcomputer-based instruction. Applications development will involve the application and design of advanced 3D animation, digital sound, and video overlay techniques. Interactive Multimedia Programming and Hypermedia Theory and Practice or consent of the instructor required.

EdT 407. Foundations of Educational Technology (3)
Examination of the effects of recent developments in communications technology, cognitive psychology, computer science, and related disciplines upon the educational process.

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 423. Instructional Programming in LOGO (3)
Hands-on experience with LOGO as a programming language and a philosophy of education. Study of turtle geometry procedures, recursion, words and lists, hierarchical structures, and interactive programming. Case studies of LOGO applications in various settings and with various computer systems.

EdT 425. Learning, Technology and Society (3)

A general survey of the impact of educational technology on modern society. Special attention to the use of large-scale data banks and retrieval systems, problems of privacy, impact of automation on everyday life, and effects of the new learning technologies on curriculum development and education configurations.

EdT 427. Educational Technology and Instructional Games and Simulations (3)
An examination of the motivational, technical, and instructional issues related to the design of microcomputer/video educational games and simulations. Course requirements will include designing and programming an instructional game or simulation.

EdT 433. Introduction to Instructional Design (3)
Key components in the systematic design of instruction, with an emphasis on the use of instructional design models, both behavioristic and cognitive, to create effective instruction. Actual design of instructional materials employing design models used in education and industry.

EdT 435. Interactive Learning (3)
Introduction to the utilization of interactive television, videodisc technology, CD-ROM and other high technologies for producing instructional software.

EdT 436. Advanced Programming and Applications in Logo (3)
Advanced programming in Logo, with special emphasis on interactive programs, recursion, and advanced use of lists (for example, association lists and manipulating programs as data). Analysis of current practices and issues related to Logo in education. Prerequisite: EdT 423 or equivalent.

EdT 443. Microcomputer-Aided Instruction (3)
Design and development of microcomputer-assisted instructional units. Students design, program and test microcomputer-aided instructional units as a drill, practice, tutorial, and simulation exercises.

EdT 453. Advanced Seminar in Instructional Design (3)
Advanced instructional design issues related to technology-based instruction. Design of integrated instructional environments, selection of instructional metaphors, the impact of the interface on the user, and preparation of documentation and accompanying materials with emphasis on design of interactive multimedia instructional environments. Prerequisite: EdT 433 or consent of instructor.

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)
Examination of current issues and practices related to the field of educational technology. Topics will vary (e.g., The Role of Educational Technology in Teaching Persons with Special Needs; The Role of Educational Technology in Teaching Preschool/Nursery School Children; Educational Implications of Sound and Graphics. May be repeated for credit as topic varies.

School Psychology
SchP 402. (SpEd 402, Psy 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 1 credit of SchP 431.

SchP 413. Advanced Research Methodology Seminar-I (1)
First of two semester courses covering advanced topics in research design, methodology, and analysis. Prerequisite: admission to doctoral program.

SchP 414. Advanced Research Methodology Seminar-II (1)
Continuation of SchP 413. Prerequisite: admission to doctoral program and SchP 413.

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, 423.

SchP 426. Advanced Child Behavior Therapy (3)
Techniques of child behavior therapy applied in classrooms and clinical settings. Particular emphasis on self-control procedures, such as social skills training, self-instruction training, and cognitive behavior therapy. Course covers both the theoretical and practical components of procedures. Prerequisite: SchP 402.

SchP 427. (CPsy 427) Standardized Tests and Measurements (3)
Principles of psychological measurements utilizing assessment techniques with focus upon standard group and individual tests. Administration and interpretation of tests.

SchP 429. Special Topics in School Psychology (with subtitle) (1-3)

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. Practicum in Interventions for Students with Behavior Disorders (1-3)
Supervised experience in designing and implementing interventions in classrooms for students with behavior disorders. 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 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 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 322. Integration (3)
Theory and application of the basic concepts on integration. Emphasis on educating students with special needs in regular school and classroom environments.

SpEd 323. Introduction to Mild Disabilities (3)
An intensive introduction to direct instruction, behavioral interventions, social skills training, curriculum based assessment, IEPs, classroom structure for those who need emotional and learning support (e.g., learning disabilities, serious emotional disturbances and mild mental retardation).

SpEd 324. Introduction to Severe Disabilities (3)
An intensive introduction to a life skills approach to curriculum, including systematic instruction, data based decisions, community based instruction, behavior management, integration and IEPs or IHPs for students who need a life skills approach (e.g., autism, severe/profound mental retardation, cerebral palsy, multihandicaps).

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 331. (Psych 352) Emotional and Behavioral Disorders of Children (3)
Definition, classification, etiology, treatment, and historical perspective of children and adolescent disorders.

SpEd 332. Education of Individuals with Special Needs (3)
Legal, educational, and social issues related to the special education of people with mental retardation, physical handicaps, emotional/behavior disorders, learning disabilities, visual and hearing impairments, health impairments and those who are intellectually gifted.

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 339. Learning Disabilities (3)
Definition, classification, etiology, treatment, and historical perspective of individuals with learning disabilities.

SpEd 402. (SchP 402, Psych 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 education assessment and interviews. Utilization of curriculum based assessment.

SpEd 417. Language and Social Skills (3)
Empirically based strategies to teach skills in nonvocal communication, early language, conversational skills, grammar and other communication skills to individuals with mild or severe disabilities.

SpEd 418. Teaching Individuals with Severe Disabilities (3)
Curriculum and methods for life skills instruction—self care, daily living, community based instruction, communication, social integration, vocational training, functional academics.

SpEd 419. Teaching Individuals with Mild Disabilities (3)
Emphasis on effective teaching techniques for academic and social skills. Emphasis on curriculum development and instructional strategies in language arts, math, and other academic content areas.
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 this 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 425. Specialization Internship (3)
Competency based practice to develop specific expertise in Behavior Disorders, Severe Disabilities, Consulting Teacher or Early-childhood. May be repeated for credit in more than one specialty. Prerequisite: consent of program coordinator one semester before registering.

SpEd 428. Advanced Behavior Management for Individuals with Severe Disabilities (3)
This course will develop skills in long-term remediation of problem behaviors characteristic of persons with severe disabilities through functional assessments, positive procedures, and lifestyle interventions.

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 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. Alastair D. McAulay, Ph.D. (Carnegie Mellon), chair and Chandler-Weaver professor; Frank H. Hsielson, Ph.D. (Illinois) associate chair; Donald J. Hillman, Ph.D. (Cambridge, England), head of computer science division; D. Richard Decker, Ph.D. (Lehigh); Bruce D. Fritchman, Ph.D. (Lehigh); Samuel L. Guelden, M.A. (Princeton); Miltiades Hatalis, Ph.D. (Carnegie Mellon); Carl S. Holzinger, Ph.D. (Lehigh); James C. M. Hwang, Ph.D. (Cornell); Edwin J. Kay, Ph.D. (Lehigh); Roger N. Nagel, Ph.D. (Maryland), Harvey E. Wagner, professor of manufacturing systems engineering; Kenneth K. Tseng, 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); Terrance E. Boult, Ph.D. (Columbia); Dragana Brzakovic, Ph.D. (Florida); Demetrios Christodoulides, Ph.D. (Johns Hopkins); Douglas R. Frey, Ph.D. (Lehigh); Weiping Li, Ph.D. (Stanford); Karl H. Norian, Ph.D. (Imperial College, London); Patti T. Ota, Ph.D. (Pennsylvania), vice provost for academic administration; Meghanad D. Wagh, Ph.D. (I.I.T., Bombay).

Assistant professors. Hassan Barada, Ph.D. (Louisiana State); Rick S. Blum, Ph.D. (Pennsylvania); Adair Dingle, Ph.D. (Texas-Dallas); Madalene Speziali, Ph.D. (Pittsburgh).


Emeritus professors. John J. Karakash, Eng.D. (Hon.) (Lehigh); Robert F. Barnes, Ph.D. (Berkeley); Walter E. Dahlke, Ph.D. (Jena, Germany); Nikolai Eberhardt, Ph.D. (Munich, Germany); Ralph J. Jaccodine, Ph.D. (Notre Dame); Arthur I. Larky, Ph.D. (Stanford); Daniel Leennev, Ph.D. (Chicago); John J. O’Connor, Ph.D. (Columbia); Gerhard Rayna, Ph.D. (Princeton); Donald L. Talhelm, M.S. (Lehigh); Eric D. Thompson, Ph.D. (M.I.T.); Lawrence J. Varnerin, Ph.D. (M.I.T.); Donald R. Young, Ph.D. (M.I.T.).

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 College of Engineering and Applied
Science in electrical engineering, computer engineering, and computer science, and it offers the bachelor of science and bachelor of arts degree with a major in computer science from the College of Arts and Science. 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 his program according to his 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, lightwave laboratory, digital signal processing laboratory, parallel computing laboratory, and the digital systems laboratory. The department has research laboratories in artificial intelligence, computer architectures; design and computing systems; electron device physics; microelectronics fabrication; microwave monolithic circuits; microwave and VLSI measurements. These laboratories are described more completely in the departmental graduate brochure. These laboratories, among others, are available for undergraduate projects.

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 natural 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 more than 125 IBM RS/6000 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 Computer Center (LUCC) systems. The primary department resource is a network of more than 20 Sun Sparc workstations, file servers, and compute servers, running the Unix operating system. With over 15 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, ...), software development tools, software and 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, and a 64 node multiprocessor transputer for parallel processing instruction and research. The workstations and microcomputers are connected via multiple high-speed ethernet and fiber optic networks, which are in turn connected to the university's backbone network, the Pennsylvania Research and Economic Partnership Network (PREPNET), and 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

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 135 credit hours. The recommended sequence of courses follows:

<table>
<thead>
<tr>
<th>Fr es hman year</th>
<th>Sophomore year, first semester</th>
<th>Sophomore year, second semester</th>
<th>Junior year, first semester</th>
<th>Junior year, second semester</th>
<th>Senior year, first semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECE 33</td>
<td>Introduction to Computer</td>
<td>ECE 81 Principles of Electrical Engineering</td>
<td>ECE 121 Electronic Circuits Laboratory (2)</td>
<td>ECE 126 Fundamentals of Semiconductor Devices (3)</td>
<td>ECE 111 Proseminar (1)</td>
</tr>
<tr>
<td>ECE 81</td>
<td>Principles of Electrical</td>
<td>ECE 123 Electronic Circuits</td>
<td>ECE 123 Complex Variables</td>
<td>ECE 136 Electromechanics</td>
<td>ECE 251 Senior Project I</td>
</tr>
<tr>
<td>Phy 21, 22</td>
<td>Engineering (4)</td>
<td>ECE 125 Circuits and Systems (3)</td>
<td>HSS elective (3)</td>
<td>ECE 138 Digital Systems</td>
<td>ECE 203 Introduction to</td>
</tr>
<tr>
<td>Math 23</td>
<td>Laboratory II (5)</td>
<td>Math 208 HSS elective (3)</td>
<td>approved technical elective* (3)</td>
<td>Laboratory (2)</td>
<td>Electromagnetic Waves (3)</td>
</tr>
<tr>
<td>Eco 11 or 12</td>
<td>Analytic Geometry and Calculus III (4)</td>
<td>approved technical elective* (6)</td>
<td>free elective (3)</td>
<td>ECE 231 Probability and</td>
<td>HSS elective (3)</td>
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<td></td>
<td></td>
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<td></td>
<td>Statistics (3)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Senior year, second semester</th>
<th>(18 credit hours)</th>
<th>approved technical electives* (12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSS elective (3)</td>
<td>free elective (3)</td>
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</tr>
</tbody>
</table>

*Approved technical electives are subjects predominantly in the area of science and technology. They are not restricted to offerings in the department of computer science and electrical engineering. Students must choose at least one elective in either materials, mechanics, thermodynamics, fluid mechanics or physical chemistry, and at least one elective in physics, chemistry, biology or earth and environmental sciences. For students interested in solid-state electronics, quantum mechanics is recommended.

Bachelor of Science in Computer Engineering

The required courses for this degree contain the fundamentals of electronic circuits, signal theory, logic design, computer architecture, structured programming, data structures, software engineering, discrete mathematics, and numerical analysis. A strong foundation in the physical sciences and in mathematics is required. Approved technical 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:

<table>
<thead>
<tr>
<th>Fr es hman year</th>
<th>Sophomore year, first semester</th>
<th>Sophomore year, second semester</th>
<th>Junior year, first semester</th>
<th>Junior year, second semester</th>
<th>Senior year, second semester</th>
<th>Sophomore year, second semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECE 81</td>
<td>Introduction to Electrical</td>
<td>ECE 82 Sophomore Laboratory (1)</td>
<td>ECE 121 Electronic</td>
<td>ECE 126 Fundamentals of</td>
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<tr>
<td></td>
<td>Engineering (4)</td>
<td>ECE 108 Signals and Systems (4)</td>
<td>Circuits Laboratory (2)</td>
<td>Semiconductor Devices (3)</td>
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</tr>
<tr>
<td>ECE 33</td>
<td>Introduction to Computer</td>
<td>Math 205 Linear Methods (3)</td>
<td>Math 208 Probability and</td>
<td>ECE 136 Electromechanics</td>
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</tr>
<tr>
<td></td>
<td>Engineering (4)</td>
<td>Eco 11 or 12 Micro-or</td>
<td>Statistics (3)</td>
<td>HSS elective (3)</td>
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<td></td>
<td></td>
<td>Macroeconomics (3)</td>
<td>free elective (3)</td>
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<td></td>
<td></td>
<td>Math 205 Linear Methods (3)</td>
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<tr>
<td></td>
<td></td>
<td>Eco 11 or 12 Micro-or</td>
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<td>Math 205 Linear Methods (3)</td>
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<td>Math 205 Linear Methods (3)</td>
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<td>HSS elective (3)</td>
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</tbody>
</table>

*Approved technical electives are subjects predominantly in the area of science and technology. They are not restricted to offerings in the department of computer science and electrical engineering. Students must choose at least one elective in either materials, mechanics, thermodynamics, fluid mechanics or physical chemistry, and at least one elective in physics, chemistry, biology or earth and environmental sciences. For students interested in solid-state electronics, quantum mechanics is recommended.
Math 309  Theory of Probability (3)  
approved technical elective* (3)  
free elective (3)

junior year, second semester (17 credit hours)
ECE 116  Software Engineering (3)  
ECE 138  Digital Systems Laboratory (2)  
ECE 201  Computer Architecture (3)  
CSc 261  Discrete Structures (3)  
free elective (3)  
HSS elective (3)

senior year, first semester (18 credit hours)
ECE 111  Proseminar (1)  
ECE 251  Senior Project I (2)  
ECE 319  Digital System Design (3)  
CSc 303  Operating System Design (3)  
HSS elective (3)  
approved technical elective* (3)  
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. 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.

Bachelor of Science in Computer Science

Two degree programs are available to students through either the College of Arts and Science or the College of Engineering and Applied Science. The program offered by the 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 Science program requires 124 credit hours whereas the 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 pages 33 for the distribution requirements of the College of Arts & Sciences

freshman year, first semester (16 credit hours)
Engl 1  Composition and Literature (3)  
Math 21  Analytic Geometry and Calculus I (4)  
CSc 11  Introduction to Structured Programming (3)*  
distribution (6)

freshman year, second semester (16 credit hours)
Engl 2  Composition and Literature: Fiction, Drama, Poetry (3)  
Math 22  Analytic Geometry and Calculus II (4)  
CSc 15  Data Structures (3)*  
distribution (6)

sophomore year, first semester (17 credit hours)
Math 23  Analytic Geometry and Calculus III (4)  
ECE 33  Introduction to Computer Engineering (4)  
distribution (9)

sophomore year, second semester (15 credit hours)
Math 205  Linear Methods (3)  
ECE 116  Software Engineering (3)  
CSc 109  Systems Programming (3)  
approved technical electives** (3)  
distribution (3)

junior year, first semester (15 credit hours)
Math 231  Probability and Statistics (3) or  
Math 309  Theory of Probability (3)  
CSc 209  Assembly Language Programming (3)  
CSc 261  Discrete Structures (3)  
approved technical elective** (6)

junior year, second semester (15 credit hours)
CSc 252  Computers and Society (3)  
CSc 262  Programming Languages (3)  
CSc 340  Design and Analysis of Algorithms (3)  
ECE 201  Computer Architecture (3)  
approved technical electives** (3)

senior year, first semester (15 credit hours)
Math 230  Numerical Methods (3) or  
Engr 250  Computer Modeling of Scientific & Engineering Systems (3)  
CSc 303  Operating System Design (3)  
CSc 318  Automata & Formal Grammars (3)  
approved technical electives** (3)  
distribution (3)
senior year, second semester (15 credit hours)
CSc 302 Compiler Design (3)
approved technical electives** (9)
distribution (3)

*With approval, CSc 17, Structured Programming and Data Structures (4), and a 3 credit hour approved technical elective may be substituted for CSc 11 and CSc 15.

**Approved technical electives are chosen by the student, with the approval of the major advisor, to support the professional objectives of the student.

Senior year, second semester (18 credit hours)
CSc 303 Operating System Design (3)
CSc 318 Automatic & Formal Grammars (3)
HSS elective (3)
free elective (3)

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:

Bachelor of Arts in Computer Science

freshman year, first semester (16 credit hours)
Engl 1 Composition and Literature (3)
Math 21 Analytic Geometry and Calculus I (4)
CSc 11 Introduction to Structured Programming (3)*
distribution (6)

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)
ECE 201 Computer Architecture (3)
CSc 109 Systems Programming (3)
distribution (6)

Junior year, first semester (15 credit hours)
CSc 209 Advanced Programming (3)
Csc 262 Programming Languages (3) 
distribution (6) 
free electives (3)

**junior year, second semester** (15 credit hours) 
distribution (6) 
free electives (9)

CSc 303 Operating System Design (3) 
CSc 318 Automata and Formal Grammars (3) 
distribution (3) 
free electives (6)

**senior year, first semester** (15 credit hours) 
CSc 302 Compiler Design 
(3) 
distribution (3) 
free electives (7)

**senior year, second semester** (13 credit hours) 
CSc 302 Compiler Design 
(3) 
distribution (3) 
free electives (7)

*With approval, CSc 17, Structured Programming and Data Structures (4), and a 3 credit hour approved technical elective may replace CSc 11 and CSc 15.

**Minor in Computer Science**

The minor in computer science provides a concentration which includes discrete mathematics, structured programming concepts, programming languages, and computer organization, essential elements of computer science. This minor is not available to students of the Department. The minor is as follows:

Math 21 Analytic Geometry and Calculus I (4) 
CSc 261 Discrete Structures (3) 
CSc 11 Introduction to Structured Programming (3)* 
CSc 15 Data Structures (3) * 
ECE 33 Introduction to Computer Engineering (4) 
CSc 241 Data Base Systems (3) or 
CSc 262 Programming Languages (3) 

(20 credit hours)

*With approval, CSc 17, Structured Programming and Data Structures (4), can be substituted for CSc 11 and CSc 15 for an 18 credit hour minor.

**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.
The reader is urged to consult both listings.

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. Special topics courses are restricted to six credit hours. 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 graduate school 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 likely to be found under either prefix. The reader is urged to consult both listings.

**Computer Science (CSc)**

**For Undergraduate Students**

CSc 11. Introduction to Structured Programming (3)

Algorithmic design and implementation in high-level, block-structured, procedure-oriented languages. No prior computing experience required. (ES 2), (ED 1)

CSc 15. Data Structures (3)

Continuation of CSc 11. Data structures using pointer variables. Prerequisite: CSc 11. (ES2), (EDI)

CSc 17. Structured Programming and Data Structures (4)

Algorithmic design and implementation in high level, block-structured, procedure-oriented languages. Recursion, lexical programs, pointers, data structures, and their applications. Previous experience with programming required. NOTE: CSc 17 constitutes an accelerated course for students with some programming experience, which can be used as a prerequisite in place of CSc 11 and 15. Students may not receive credit for both CSc 11 & 15 and 17. (ES 3), (ED 1)

CSc 109. Systems Programming (3)

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 or CSc 15, 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)

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) spring

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.

CSc 261. (Math 261) Discrete Structures (3)

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), (ED1)

CSc 262. Programming Languages (3) fall and spring

Use, structure and implementation of several programming languages. Prerequisite: CSc 15 or 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. Prerequisites: ECE 33 and either CSc 17 or CSc 15. (ES 2), (ED 1)

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: CSc 109 and ECE 201. (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)
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 116.

CSc 340. (Math 340) Design and Analysis of Algorithms (3)
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. Prerequisite: CSc 15 or Math 23 or consent of the division head. (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) spring
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 375. 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 multi-programming 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, back-tracking, 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 15 or 17 or consent of the division head. Gulden

CSc 412. Object Oriented Programming
Objects, messages, classes and inheritance; the model-view-controller 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 knowledge-based 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, compiler 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 Engineering (ECE)

For Undergraduate Students

ECE 33. Introduction to Computer Engineering (4) fall and spring
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 I or CSc 15 or CSc 17. (ES 2), (ED 2)

ECE 81. Principles of Electrical Engineering (4) fall and spring

ECE 82. Sophomore Lab (1)
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 3-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 .5), (ED .5)

ECE 116. 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. (ES 1.5), (ED 1.5)

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 .5), (ED 1.5)

ECE 123. 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.), (ED 1.5)

ECE 125. Circuits and Systems (3) fall
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 .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 and 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 .5)

ECE 136. Electromechanics (3) spring
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 electromechanical transducers, transformers, AC and DC machines. Prerequisite: ECE 81. (ES 1.5), (ED 1.5)

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 .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 pipelining. 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) spring
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. Prerequisite: Math 205, Phys. 21. (ES 3), (ED 0)

ECE 203. Introduction to Electromagnetic Waves (3) fall
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 1.5)

ECE 212. Control Theory (3) fall

ECE 233. Power System Analysis I (3) fall
Determination of transmission line constants: transmission line equations. Synchronous generator representation during steady state and transient conditions. Network reduction by matrix partitioning, network solutions by matrix transformations. Symmetrical components and system faults. Sequence impedances of transmission lines, transformer banks and synchronous generators. Prerequisite: ECE 136. (ES 2.5), (ED 1.5)

ECE 234. Power System Analysis II (3)
Load flow applications of the control of power and voltage. Economic dispatch of generation. Short circuit analysis. Power system protection. Basic stability analysis. Engineering Economics. Current topics of interest with the power industry. Prerequisite: ECE 233. (ES 2), (ED 1)

ECE 244. Analog Filters (3)
Approximation of ideal filters by practical filters. Frequency scaling and transformation. Analog filter synthesis using active devices. Switched capacitor implementations of analog filters. Prerequisites: ECE 123 and ECE 125. (ES 2), (ED 1)

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 computing 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) spring
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 1), (ED 2)

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) spring**
Review of basic switching theory, vector boolean algebra, canonical implementations of medium size circuits, threshold logic, fault detection in combinational and sequential logic, Multiposition 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) spring**
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. Prerequisite: ECE 355. Frey. (ES), (ED)

**ECE 333. Medical Electronics (3) fall**
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, bioamplifiers, pulse circuits and their applications. Prerequisite: ECE 123 or equivalent. Norian. (ES 2.5), (ED)

**ECE 340. Adaptive Signal Processing (3) spring**
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 lattice 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), (ED)

**ECE 342. Communication Theory (3) spring**
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 221. (ES), (ED)

**ECE 343. Digital Signal Processing (3) fall**
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)

**ECE 344. Statistical Signal Processing (3) spring**
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), (ED)

**ECE 345. Speech Synthesis and Recognition (3) spring**
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)

**ECE 346. Microwave Circuits and Techniques (3) spring**

**ECE 347. Introduction to Integrated Optics (3) fall**

**ECE 348. Lightwave Technology (3) spring**
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), (ED)

**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) fall
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) fall
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 multipliers, modulators, and phase-locked loops. Prerequisites: ECE 108 and 123. Holzinger. (ES 1), (ED 2)

ECE 361. Introduction to VLSI Circuits (3) fall
The design of Very Large Scale Integrated 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) spring
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 361. Hielscher. (ES .5), (ED 2.5)

ECE 371. Optical Information Processing (3) spring
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 .5), (ED 2.5)

ECE 372. Optical Networks (3) spring
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 multiascess systems. The class is supported with a laboratory. Prerequisite ECE 81. McAulay, (ES 1), (ED 2)

ECE 375. Computer Vision (3) fall
Acquisition and processing of digital images. Interpretation of vision modalities. Intermediate level vision, including segmentation, texture, shading and photometric stereo. Basics of high level vision. Prerequisite: ECE 343 or equivalent or consent of instructor. Brzakovic. (ES 1), (ED 2)

ECE 377. (ChE 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. Prerequisite: ChE 386 or ECE 212 or ME 342 or consent of instructor. (ES 3), (ED 0)

ECE 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. Prerequisite: ChE 386, ME 343, ECE 212. (ES 2), (ED 0)

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 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. Tzeng

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, solitons, etc. Photorefractive effect. Brillouin and Raman scattering. Christodoulides

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. Fritchman

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 413. Data Communication (3)
Review of data transmission system evolution. Description of devices and techniques used for reliable transmission of data between systems connected by point-to-point data links. Study of protocols and equipments used in terminal oriented distributed computing systems. Review of different types of communication protocols using queuing theory for analysis of their fundamental properties.

ECE 414. Signal Detection and Estimation (3) spring
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, CORDIC trigonometric calculator, accumulator orientations, bit slice and bit-sequential processors, pipelining and parallel processing considerations. Prerequisite: ECE 201. Wagh

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. Li

ECE 417. Pattern Recognition (3)

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. Wagh

ECE 432. Finite State Machines (3)
Structure of sequential machines. State minimization. State Partitions. Properties and synthesis of finite automata. Linear sequential machines over finite fields. State-space analysis and
properties of linear sequential machines. Synthesis of regular expression recognizers. Prerequisite: ECE 320 or consent of the instructor. Wagh

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) feedforward 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; construction of Goppa codes and their recent generalizations. 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, quasi-linearization 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 441. Advanced Electromagnetic Theory (3)

ECE 444. Microwave Devices (3)
Basic theory, design theory and intuitive understanding are developed for passive and active devices and special circuitry used in microwave systems: circulators, isolators, directional couplers, periodic structures, parametric amplifiers, masers, magnetrons, and klystrons. Semiconductor devices are only discussed by their terminal characteristics.

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, electronic and thermal conduction. Magnetic effects. Generation and recombination theory. Application to p-n junctions. Prerequisites: Phys 31 and ECE 126 or equivalent. Decker or White

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 454. Theory of Optoelectronic Devices (3)
Optical electronics. Theory of radiation, radiative absorption and emission in semiconductors. Applications to optical

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) Fall
This course covers the main characterization techniques used in semiconductor industry. Emphasis is given to the electrical characterization methods although some optical, and physical analytical techniques are reviewed. The principles and the experimental setup 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 468. Solid-State Microelectronics Technology (3)
Laboratory fabrication of CMOS/Bipolar integrated circuits and device test structures. The emphasis is on practical aspects of IC fabrication including silicon wafer cleaning, patterning of defects, oxidation, diffusion, ion-implantation, photolithography, chemical vapor deposition, plasma and wet-chemical processes, and vacuum evaporation/sputtering of metal and dielectric films. Contamination and safety are emphasized throughout the process sequence. Inprocess monitors and computer simulation of technology steps are combined with laboratory experiments. Each student fabricates a complete IC "chip" and performs technology evaluation with on-chip test structures. Registration by consent of instructor. Prerequisite: ECE 351 or equivalent. White

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 471. Device Modeling for VLSI Circuits (3)
VLSI design requires computer aids for all aspects of the design and verification process. This course will take a close look at the physics of the device models of the various semiconductor components, and how these models have been implemented in SPICE. Course coverage will include the various well-established models, such as the Gummel-Poon model of the bipolar transistor, as well as the second-order effects of both bipolar and field-effect devices. Prerequisite: ECE 308. Hielscher

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 loads; 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 471 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 471. 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 361 and ECE 471. 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 484. Dielectric Materials in VLSI and Optoelectronics (3)
Electronic and optical properties of silicon dioxide and other dielectric materials, including optical excitations, charge carrier transport and trapping, and interface phenomena. Applications to dielectric crystal, film, used in VLSI technologies. Emphasis on specific topics of current interest. Prerequisite: ECE 451 or equivalent.

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 I.C.'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 161 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 129 credit hours, including all of the required electrical engineering courses, by the end of the fourth year and the rest of 161 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 six extra credit hours through advanced placement and/or overload credits.

In the alternate course sequence in the column on the right, the student completes 131 credit hours by the end of the fourth year, including all the required physics courses, and the rest of the 161 credits at the end of the fifth year. Since 127 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.

Interested students should contact Prof. S. H. Radin, department of physics.

The recommended sequences of courses for the two different sequences are:

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<td>EE-EP</td>
<td>ECE 33 (4) ECE 33 (4)</td>
<td>ECE 33 (4) ECE 108 (4)</td>
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<td>ECE 251 (2) Phys 340 (3)</td>
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<td>Phys 273 or ECE 251 (2)</td>
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<td>Phy 171 (1) ECE approved elective (9)</td>
<td>Phy 261 (2) ECE approved elective (9)</td>
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Phy approved elective** (3)
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**Approved electives include two courses selected from Phy 363, 369, (352 or 355), and (346 or 365). Students planning graduate work in physics are advised to include Phy 273 and 369 among their electives.

Engineering

Engr 1 is required of all engineering and applied science majors and is taken in the recommended freshman year.

1. Engineering Computations (3) fall-spring
Introduction to the solution of engineering problems through the use of the computer. Elementary computer programming in FORTRAN is taught and illustrated by means of several topics in computational mathematics such as roots of equations, matrices, least squares analysis, numerical integration, and others. No previous knowledge of computer programming is assumed. Prerequisite: Math 21 or 31, previously or concurrently. ES(1)

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 College of Engineering and Applied Science in the semester opposite that in which ENGR 1 is rostered. Pass-fail grading.

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)

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) head; Terry J. Delph, Ph.D. (Stanford); Fazil Erdogan, Ph.D. (Lehigh); Stanley H. Johnson, Ph.D. (Berkeley); Arturs Kalnins, Ph.D. (Michigan); Jacob Y. Kazakia, Ph.D. (Lehigh); Alistair K. Macpherson, Ph.D. (Sydney); Kenneth N. Sawyers, Ph.D. (Brown); George C. M. Sih, Ph.D. (Lehigh); Gerald F. Smith, Ph.D. (Brown); Eric Varley, Ph.D. (Brown); J. David A. Walker, Ph.D. (Western Ontario).

Associate professors. D. Gary Harlow, Ph.D. (Cornell).

Assistant professors. Antonios Liakopoulos (Florida).

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 on page 49 in Section IV. Engineering Mathematics courses are listed under Mechanical Engineering and Mechanics.

English

Professors. Barbara H. Traister, Ph.D. (Yale); chairperson; Rosemarie A. Arbur, Ph.D. (Illinois); 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. Fife, Ph.D. (Michigan); James R. Fairchild Professor of American Studies; Edward J. Gallagher, Ph.D. (Notre Dame); Barry M. Kroll, Ph.D. (Michigan), Robert D. Rodale Professor of Writing; Rosemary J. Mundhenk, Ph.D. (U.C.L.A.).

Associate professors. Alexander M. Doty, Ph.D. (Illinois); Edward E. Lotro, Ph.D. (Indiana) director, 110 Drown ; Barbara Pavlock, Ph.D. (Cornell).

Assistant professors. Scott P. Gordon, Ph. D. (Harvard); David Hawkes, Ph.D. (Columbia); Patricia C. Ingham, Ph.D. (UC Santa Barbara).

Adjunct professors. Carolyn Segal, Ph.D. (Lehigh).

"Nature is a Haunted House," Emily Dickinson wrote to a friend in 1876, "but Art—a House that tries to be haunted." In the Department of English we try to tease forward the spirits that give life to houses built of words.
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 and a deeper study of two major writers, each English major is required to take the following courses:

- Engl 123, American Literature I,
- Engl 125, British Literature I, and
- Engl 126, British Literature II;

   either

- Engl 329, Shakespeare and Elizabethan Drama, or
- Engl 330, Shakespeare and Elizabethan Drama;

   and either

- Engl 327, Chaucer, or
- Engl 331, Milton.

In addition, each English major elects at least five more courses in literature or film distributed as follows:

- at least three courses at the 300-level, and
- at least two courses in literature before 1900.

These ten 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 36 credit hours of course work in English (beyond English 1 and 2). For the additional credits beyond the 30 required of all English majors, honors students must take one of the following three courses:

- Engl 248, Introduction to the English Language, or
- Engl 387, Film History and Criticism, or
- Engl 390, Interpretative Approaches to Literature;

   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.

Minors in English

The Department of English offers three minors, each requiring fifteen 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 three more courses in British literature, at least two of them at the 300-level.

To minor in American literature, students take Engl 123, Engl 124, and three more courses in American literature, at least two of them at the 300-level.

To minor in writing, students take Engl 171 and one of these two courses: Engl 347 or Engl 373. They must also take three more courses chosen from Engl 173, 174, 201, 248, 281, Journ 11, 12, 123, or any literature courses designated writing intensive (WI).

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 M.A. degree must complete at least thirty 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. course work and strong endorsements from graduate instructors are minimum requirements for acceptance.

Doctoral candidates with a Lehigh master's degree must register for 42 credit hours beyond the M.A. Those entering the doctoral program with a master's from another institution must register for 48 credit hours. Candidates take at least twenty-four hours of course work beyond the M.A., including at least one course from the following sequence: English 421 (History of the English Language), English 423 (Old English), and English 424 (Beowulf).

Candidates must also demonstrate a reading knowledge of one or two foreign languages after having agreed in 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 Graduate School.

Freshman Composition Requirement

With the two exceptions noted below, all undergraduate students take six credit hours of freshman English: English 1 and one of the five options for the second semester, Engl 2, 4, 6, 8, or 10. The exceptions are:

1. Advanced placement and six hours of Lehigh credit for freshman English are given to students who earn a score of 5 on the College Board Advanced Placement Test in English. Students who receive a grade of 4 on the Advanced Placement Test in English or who have a score of 700 or higher on the SAT Verbal Aptitude Test or the English Composition Achievement 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. Students who have an SAT Verbal Aptitude Test or English Composition Achievement Test score between 650 and 699 or who have received a grade of 3 on the College Board Advanced Placement Test in English may apply to the department for a special examination given during orientation, which, if completed successfully, will result in three hours of credit and exemption from Engl 1.

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 interested in these categories must petition for special instruction through the program in English as a Second Language. At matriculation, all foreign students take an English language competence test to determine the kind of instruction best suited to their needs. Matriculating freshmen judged to be qualified will roster Engl 1, followed by Engl 2, 4, 6, 8, or 10. Others will be enrolled in Engl 3, followed by Engl 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

1. Composition and Literature (3)

The art of expository writing. Appropriate collateral reading.

2. Composition and Literature: Fiction, Drama, Poetry (3)

Continuation of Engl 1. Further practice in expository writing in conjunction with the study of fiction, drama, and poetry. Prerequisite: Engl 1.

3. English as a Second Language (3)

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.

4. Composition and Literature: The Novel (3) spring

Continuation of Engl 1. Further practice in expository writing in conjunction with study of selected novels. Prerequisite: Engl 1.

5. English as Second Language II (3)

Continuation of English 3.
6. Composition and Literature: Drama (3) spring
Continuation of Engl 1. Further practice in expository writing in conjunction with the study of literary and theatrical aspects of several classic and contemporary plays. Prerequisite: Engl 1.

8. Composition and Film Study (3) spring
Continuation of Engl 1. Further practice in expository writing in conjunction with the study of film. Prerequisite: Engl 1.

10. Composition and Literature: Fiction (3) spring
Continuation of Engl 1. Further practice in expository writing in conjunction with the study of short stories, novellas, and novels. Prerequisite: Engl 1.

11. Literature Seminar for Freshmen (3) fall
Discussion of and writing about selected masterworks of literature. Open as an elective to any freshman exempt from the regular freshman English requirement.

Undergraduate Courses
English 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 Eng 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 Eng 126 whether or not they have had, or ever plan to take, Eng 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.

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. Scott. (HU)

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)

54. Greek Tragedy (3)
Aspects of Greek theater and plays of Aeschylus, Sophocles, and Euripides in their social and intellectual contexts. Pavlock. (HU)

56. The Ancient Novel (3)
Examination of the origins of the novel in Greece and Rome. Includes the picaresque novel. Pavlock. (HU)

58. Greek and Roman Comedy (3)
Study of comedy as a social form through plays of Aristophanes, Menander, Plautus, and Terence. Pavlock. (HU)

91. Special Topics (1-3)
A topic, genre, or approach in literature or writing not covered in other courses. (HU)

120. Literature from Developing Nations (3)
Contemporary literature from Africa, Central and South America, and Asia. Prerequisite: six hours of freshman English. Fifer. (HU)

122. Speculative Fiction (3)
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. Arbur. (HU)

123. American Literature I (3)
American literary works through the mid-19th century. Prerequisite: six hours of freshman English. (HU)

124. American Literature II (3)
American literature from the middle of the 19th century to the present. Prerequisite: six hours of freshman English. (HU)

125. British Literature I (3)
British literature and literary history from Beowulf through the Pre-Romantics. Prerequisite: six hours of freshman English. (HU)

126. British Literature II (3)
British literature and literary history from the Romantic period into the 20th Century. Prerequisite: six hours of freshman English. (HU)

155. The Novel (3)
Selected novels, with attention to such matters as narrative, characterization, and cultural context. Prerequisite: six hours of freshman English. (HU)

157. Poetry (3)
Selected traditional and modern poetry, with attention to voice, form, and cultural context. Prerequisite: six hours of freshman English. (HU)

163. Narrative Film (3)
History and aesthetics of narrative film. May be repeated for credit as title varies. Prerequisite: six hours of freshman English. Doty. (HU)

171. Practical Writing (3)
Practice in and criticism of expository writing beyond the freshman level. Prerequisite: six hours of freshman English. (ND)

173. Personal Writing (3)
Practice in writing from immediate experience, with emphasis on accurate, persuasive descriptive writing. Prerequisite: six hours of freshman English. (ND)

174. Creative Writing Workshop (3)
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)

175. Individual Authors (3)
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)

177. Individual Works (3)
Intensive study of one or more literary works, such as Moby Dick and Stories of John Cheever. May be repeated for credit as works varies. Prerequisite: six hours of freshman English. (HU)

183. Independent Study (3)
Individually supervised study of a topic in literature, film, or writing not covered in regularly listed courses. Prerequisite: consent of the department chairperson. (HU)

187. Themes in Literature (3)
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)

189. Popular Literature (3)
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 vary. Prerequisite: six hours of freshman English. (HU)

191. Special Topics (1-3)
A topic, genre, or approach in literature or writing not covered in other courses. Prerequisite: six hours of freshman English. (HU)

201. Special Topics in Writing (1-3)
Approaches not covered in other writing courses. Individual projects. May be repeated for credit. Prerequisite: Engl 171, or consent of department chair. (ND)

248. Introduction to the English Language (3)
Basic linguistic concepts together with a historical survey of the English language. Ingham. (HU)

281. Internship (3)
Projects on or off campus in business, professional, or government organizations. Projects approved by department committee on internships and supervised by department internship adviser. Project includes extensive writing that can be submitted for evaluation. Enrollment limited to juniors or seniors with a major or minor in English. Prerequisite: consent of department chair. (ND)

291. Special Topics (1-3)
A topic, genre, or approach in literature or writing not covered in other courses. (HU)

301. Topics in Literature (3)
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)

307. Undergraduate Thesis (3)
Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of the department chairperson. (HU)

308. Undergraduate Thesis (3)
Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of department chairperson. (HU)

311. (WS 311) Literature of Women (3)
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. Arbur. (HU)

316. Native American Literature (3)
The Indian as portrayed in America Literature. Works written by both Indian and non-Indian writers with focus on contemporary fiction by Native American writers. Beidler. (HU)

327. Chaucer (3)
The chief works of the "father of English Literature." Focus on Chaucer's language, on the literary, historical and social backgrounds to his work, and on his masterpiece, the Canterbury Tales. Beidler. (HU)

329. Shakespeare and Elizabethan Drama (3) fall
The earlier plays of Shakespeare, mostly comedies and histories. Selected plays from contemporary dramatists such as Marlowe, and Greene. Traister. (HU)

330. Shakespeare and Elizabethan Drama (3) spring
The later plays of Shakespeare, the tragedies and romances. Selected plays from contemporary dramatists such as Webster, Tournier, Jonson. Traister. (HU)
331. Milton (3)
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)

347. Advanced Writing Workshop (3)
Sustained work in writing and revising expository prose; classroom criticism in a workshop environment; grading by portfolio. (ND)

360. Middle English Literature (3)
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)

362. The Renaissance (3)
English nondramatic literature in the 16th century, and its models from the Italian Renaissance and northern humanism. Readings from Petrarch, Erasmus, More, Wyatt, Surrey, Lyly, Sidney, Spenser, Machiavelli, and Luther. Hawkes, Traister. (HU)

364. The Seventeenth Century (3)
Literature of the 17th 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)

367. The Eighteenth Century (3)
Poetry and prose of the Restoration and Eighteenth Century, with attention to cultural forces that shaped the writers, their works, and their position in the canon. Readings from Behn, Collier, Montagu, Burney, Austen Dryden, Pope, Swift, Defoe, Fielding, and Johnson. Fergus, Scott. (HU)

369. British Romantic Literature (3)
Poetry and prose of Wordsworth, Coleridge, Byron, Shelley, and Keats within the contemporary, political, religious, and social context. (HU)

371. British Victorian Literature: Prose and Poetry (3)
Poetry and prose of Tennyson, Browning, Arnold, Swinburne, Carlyle, Mill, Newman, and Ruskin within the contemporary political, religious, and social context. Bross. (HU)

372. British Victorian Literature: Fiction (3)
Major fiction of the Victorian era by such writers as Dickens, Eliot, Thackeray, and Hardy within historical, social, and aesthetic contexts. Mundhenk. (HU)

373. Advanced Creative Writing Workshop (3)
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)

375. Major Authors (1-3)
The works of one or more major literary figures studied in depth. May be repeated for credit as titles and authors vary. (ND)

376. Early American Literature (3)
The literature of New England, the South, and the Southwest from Columbus to the close of the 18th century, emphasizing our cultural and artistic diversity. Gallagher. (HU)

377. American Romanticism (3)
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. Arbur. (HU)

378. American Realism (3)
Theory and practice of realistic and naturalistic fiction from the Civil War to the early 20th century: Twain, Howells, James, Norris, Crane, Dreiser, Wharton, and regionalists. Frakes. (HU)

379. Twentieth-Century American Literature (3)
American literature before World War II. Lectures and class discussion of major fiction and poetry. DeBellis, Mundhenk. (HU)

380. Contemporary American Literature (3)
American literature since World War II. Lectures and class discussions of new writers and of recent works of established writers. DeBellis, Frakes. (HU)

382. Themes in American Literature (3)
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)

383. Modernism and Post-Modernism in Fiction (3)
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)

385. Twentieth-Century World Literature (3)
World English literature and continental literature before World War II. Lectures and class discussion of major fiction. Frakes. (HU)

386. Contemporary World Literature (3)
Literature of Europe, Asia, Africa, and South America. World Literature in English and in translation. Fifer. (HU)

387. Film History, Theory, and Criticism (3)
Study of certain films dealing with particular genres, directors, theories, periods or themes. Doty. (HU)
388. Independent Study (1-3)
Individually supervised study of a topic in literature, film, or writing not covered in regularly listed courses. Prerequisite: consent of department chairperson. (HU)

390. Interpretation: Critical Theory and Practice (3)
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. Arbur, Bross, Mundhenk. (HU)

391. Special Topics (1-3)
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.
Courses numbered 433-477 are period courses in English and American literature. Offerings under each course number vary from year to year, and a course may be repeated for credit as the title varies. Titles listed under each graduate number are those likely to be offered in 1993-1996.

400. Supervised Teaching

421. History of the English Language (3)
The phonology, grammar, and lexicon of English from the beginnings to the present. Ingham

423. Old English (3)
Old English language and literature. Ingham

424. Beowulf (3)
The Beowulf poem and some of the pertinent scholarship. Prerequisite: English 423 or its equivalent. Ingham

427. Chaucer (3)
Chaucer's language. The Canterbury Tales. Readings, reports, and discussions. Beidler

428. Chaucer (3)
Chaucer's Minor Poems, Troilus and other pre-Canterbury period works. The 15th-century "Chaucerians." Readings, reports, and discussions. Beidler

431. Arthurian Literature of the Middle Ages (3)
Arthurian literature from its Celtic Beginnings to Malory's Morte D'Arthur. Ingham

433. Middle English Literature (3)
The Medieval Origins of English Drama: Study of several medieval plays (Everyman, Second Shepherd's Play and selected plays in one of the English mystery play cycles). Consideration also of the "dramatic techniques" of Chaucer as a precursor to the drama that was to flourish centuries later. Beidler

439. Sixteenth-Century British Literature (3)

441. Seventeenth-Century British Literature (3)

443. Eighteenth-Century British Literature (3)
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 meant to be a professional woman writer between 1770-1820. Fergus

444. Nineteenth-Century British Literature (3)
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

**445. Nineteenth-Century British Literature (3)**

**449. Twentieth-Century British Literature (3)**

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

**471. Early American Literature (3)**

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

**473. American Romanticism (3)**

Emerson, Dickinson, Frost: Emerson's philosophy, literary theory, and poetry as the context in which we consider the poetry of Dickinson and Frost. Arbur

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. Arbur

**475. American Realism (3)**

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

**477. Modern American Literature (3)**

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. DeBellis


Modern American Drama: Drama from the 1920's to the 1960's. Such playwrights as Rice, Wilder, O'Neill, Williams, Hellman, Miller, Albee. Fifer

**480. Composition and Rhetoric (3)**

Introduction to 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

**481. Theory and Criticism (3)**

Theory and practice of criticism in the study of film, literature, and composition. Offerings vary from year to year and course may be repeated for credit as the title varies. Titles below are those likely to be offered 1993-1996.

Theories of Authorship in Literature and Film: Material from Western Romanticism through theorists such as Derrida, Barthes, and Foucault. Focus on film autobiography 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 will include Macherey, Derrida, Lacan, Kristeva, and Jameson. Hawkes
485. Teaching of College English (3)
History, theory, and practice of teaching the freshman composition course. Required of all new teaching assistants in the department of English. May be rostered by others only with consent of the department chairperson.

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.

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.

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)
Program Adjunct Faculty. Laurie Cox, M.A. (U. of South Carolina), Patricia Parsons, M.A. (West Chester)

English as a Second Language courses are open to both undergraduates and graduates who wish to increase English proficiency in the areas of writing, reading, speaking, and presentation skills. The 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 ESLP courses towards an undergraduate degree. Graduate students should contact their departments regarding acceptance of credit towards residency requirements. ESLP 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 students (GCD) Program and with the permission of the ESL Director.

In 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 for ESL students, may be applied towards the composition requirement for undergraduates. See the English Department course listings for additional information.

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 instructional 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 (I)
Conversational English, colloquial language and idioms, pronunciation and accent reduction and practice in basic listening skills for an academic setting. Basic oral language development for graduate or undergraduate students. 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. For graduate and undergraduate students who wish to perfect advanced speech.

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 ESL 1 (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 reduction, and platform skills. For the undergraduate or advanced graduate student seeking formal speech skills and/or for the current or prospective teaching assistant. (Required for TAs with SPEAK scores 200 - 229.)
Prerequisite: successful completion of ESLP 2 (302) or ESLP 3 (303), or SPEAK score 180 +, or permission of ESL Director.

Environmental Writing
See Listings under Journalism and Communication

Finance

Professor. Stephen G. Buell, Ph.D. (Lehigh), chairperson, Department of Business.
Associate professors. James A. Greenleaf, Ph.D. (N.Y.U.); Richard J. Kish, Ph.D. (Univ. of Florida); Stephen F. Thode, D.B.A. (Indiana); Geraldo M. Vasconcellos, Ph.D. (Univ. of Illinois).
Adjunct professors. David L. Muething, Ph.D. (M.I.T.); Samuel C. Weaver, Ph.D. (Lehigh).

The finance major offered by the Department of Business requires fifteen credit hours beyond the core listed on page 32. Each finance major selects either the Business Finance or Financial Economics track.

Business Finance

required courses:
Fin 323 Investments (3)
Fin 328 Corporate Financial Policy (3)
plus two of the following:
Fin 324 Security Analysis (3)
Fin 330 Financial Flows and Markets (3)
Fin 331 Bank Management (3)
Fin 333 Multinational Business Finance (3)
Fin 334 Speculative Markets (3)
Fin 335 Advanced Financial Modeling (3)
Fin 336 Real Estate Finance (3)
plus one additional 300-level finance or finance/economics course.

Financial Economics

required courses:
Fin 323 Investments (3)
Fin 328 Corporate Financial Policy (3)

plus two of the following:
Fin 332 Monetary-Fiscal Policy (3)
Fin 340 International Finance (3)
Fin 353 Public Economics and Government Finance: Federal (3)
Fin 354 Public Economics and Government Finance: State and Local (3)
plus one additional 300-level finance or finance/economics course.

For Advanced Undergraduates and Graduates
Courses numbered 200 and above in the college of business and economics are open to sophomores only on petition.

225. Business Finance (3) fall, spring
Introductory corporation finance, which stresses a managerial approach to asset management and capital structure. Financial policies regarding the acquisition of funds and their allocation among competing assets within the firm. Prerequisites: Eco 145, Eco 105, Math 41 and 44, Acc 51. Buell

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 225 or permission of instructor.

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 225. Kish

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: Acc 111 and Fin 323. Not ordinarily open to CBE graduate students. Kish

328. Corporate Financial Policy (3) fall, spring
Advanced corporate finance; capital budgeting, working capital management, leasing, mergers, and financing. Case studies and complex problems. Prerequisite: Fin 225. Not ordinarily open to CBE graduate students. Thode, Kish

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 229
and Fin 225. Not ordinarily open to CBE graduate students. Vasconcellos

331. Bank Management (3) spring
Management of bank assets and liabilities within U.S. system’s legal and economic constraints. Bank Management Simulator is used to examine relationships between asset, liability, and profitability decisions. Prerequisites: Eco 229 and Fin 225 senior standing or consent of instructor. Not ordinarily open to CBE graduate students. Vasconcellos

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 229.

333. Multinational Business Finance (3) fall, spring
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

334. Derivative Securities Markets (Options, Futures, etc.) (3) spring
Theoretical and practical aspects of various instruments and markets that involve financial derivative securities (options, futures, swaps, CMO's, etc.). Emphasis on applications to corporation finance and portfolio management. Prerequisite: Fin 323. Greenleaf

335. Advanced Financial Modeling (3) fall
Modeling of complex financial decisions including bond refunding, security valuation, option pricing, currency swaps, and leasing. Utilizes the problem-solving capabilities of modern microcomputer spreadsheets. Prerequisites: Fin 323 and Fin 328 or consent of instructor. Not ordinarily open to CBE graduate students. Buell, Thode

336. Real Estate Finance (3) fall
Theoretical and empirical examination of recent developments in portfolio theory. Prerequisite: Fin 430. Muething

432. Financial Management of Financial Institutions (3) fall
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 regulations. Prerequisite: Fin 411. Vasconcellos

433. (Eco 433) Valuation Seminar (3)
Determinants of financial asset values. The role of uncertainty, imprecise forecasts, risk preferences, inflation, and market conditions. Prerequisite: Fin 411. Buell, Kish

434. Cases in Financial Management (3)
Integration of multiple topics in corporation finance through analysis of complex cases, including: capital budgeting, working capital management, leasing, mergers, and financing. Prerequisite: Fin 411. Thode

436. International Financial Management (3)
Financial management of multinational firms. Consideration of problems arising from diversity of currencies, investment opportunities, risk, and international capital markets. Case studies. Prerequisite: Fin 411. Vasconcellos

444. (Eco 444) Banking and Monetary Policy (3)
Analysis of the U.S. monetary and banking systems. Financial markets. Central bank controls, monetary theory and policy. Prerequisite: a course in money and banking. Innes

447. (Eco 447) Capital and Interest Theory (3) alternate years
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: a course in finance.

449. (Eco 449) Public Finance (3) spring, even-numbered years
The economics of public spending and taxation; principles of government debt management; theories of budgeting and cost-benefit analysis and public choice. Aronson, Munley

451. Quantitative Financial Models (3) alternate years
Relationship of quantitative models to financial theory and applications. Capital budgeting, portfolio selection, security evaluation, cash management, inventory policy and credit analysis. Prerequisite: Fin 411. Muething

456. Options and Financial Futures (3) spring
Examination of the options pricing model and its implications for options management and equity pricing. Theory and applications for hedging and speculation. Emphasis is placed on trading of options on debt, equity, stock indices and futures. Financial futures and index futures are also examined for their contributions to individual portfolio management. Prerequisite: Finance 430. Greenleaf

457. (Eco 457) 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: Eco/Fin 444 or equivalent. Innes, Callahan
459. (Eco 459) International Financial Economics (3)
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. Callahan, Gunter

471. Directed Readings (1-3)
Readings in finance not covered in regularly scheduled coursework. Prerequisite: consent of the department chairperson. May be repeated.

472. Special Topics (1-3)
Problems and issues in finance for which no regularly scheduled graduate coursework exists. When offered as group study, coverage varies according to interest in finance. Prerequisite: consent of the department chairperson. May be repeated.

See listings under Modern Foreign Languages.

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.

Fine Arts

See listings under Art and Architecture.

Five-Year Programs

Several ways exist for students to obtain two degrees in five years of study. See listings under Arts-Engineering; Arts-Master of Business Administration; Civil Engineering and Geological Sciences; Electrical Engineering and Engineering Physics; and Engineering-Master of Business Administration.

Foreign Culture And Civilization

See listings under Modern Foreign Languages.

Foreign Literature

See listings under Classics and under Modern Foreign Languages.

French
Fundamental science students are required to concentrate in a major. Students can organize acceptable programs including the substantive course elements related to any one among several areas such as chemistry, physics and mathematics, biology, earth and space science, science of living systems, materials, computer science, and architecture, or meaningful combinations of any two.

The freshman year is identical with that of all students in the 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 the inclusion of at least fifteen semester hours or from a combination that constitutes the core of one of the combination fields. Examples of these combination majors 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, and with the approval of the department chairperson concerned with the fields of concentration.

**Recommended Sequence of Courses**

**freshman engineering year** (see page 45)

**sophomore year, first semester** (15 credits)

- EES 31, 32 Introduction to Environmental and Organic Biology and Laboratory (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 11 or 12 Microeconomics or Macroeconomics (3)

**sophomore year, second semester** (17 credits)

- major subject (3)
- approved elective (3)
- Math 205 Linear Methods (3)
- Phys 21, 22 Introductory Physics II and Laboratory (5)
- HSS elective (3)

**junior year, first semester** (16 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)

**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) |

**Geophysics**

Kenneth P. Kodama, professor of geophysics, director.

Geophysics is the branch of the earth sciences in which physical principles are used to understand the subsurface geology and history of the earth. Geophysical methods are important both in the search for energy and mineral resources, the delineation of groundwater supplies and the sources of their pollution, and understanding the structure of environmental systems. On a global scale geophysics has allowed us to unravel the history of continental drift and to better understand the plate tectonic model. The program is designed to provide the background needed for graduate work in geophysics or the preparation for employment in the petroleum industry or geophysical consulting firms.

**Major Requirements for a B.S. in Geophysics** (125-126 credit hours)

**college and university requirements** (28 credits)

| Arts I | Choice and Decisions (1) |
| Engl 1 | Composition and Literature (3) |
| Engl 2, 4, 6, 8, 10 | Composition & Literature (3) |
| FS 90 | College Seminar (3) |

**distributional electives**

- Social Sciences and Humanities (18)

**free elective** (9 credits)

**major program** (88-89 credit hours)

**mathematics** (18 credit hours)

| Math 21 | Analytic Geometry and Calculus I (4) |
| Math 22 | Analytic Geometry & Calculus II (4) |
| Math 23 | Analytic Geometry & Calculus III (4) |
| Math 205 | Linear Methods (3) |
| Math 322 | Methods of Applied Analysis (3) |

**collateral sciences** (5 credit hours)

| Chm 21, 22 | Introductory Chemical Principles and Lab (4, 1) |
physics (19 credit hours)
Phys 11 Introductory Physics I (4)
Phys 12 Introductory Physics Lab I (1)
Phys 21 Introductory Physics II (4)
Phys 22 Introductory Physics Laboratory II (1)
Phys 212 Electricity and Magnetism I (3)
Phys 213 Electricity and Magnetism II (3)
Phys 215 Classical Mechanics I (3)

earth science (34-35 credit hours)
EES 21 Introduction to Earth Materials and Processes (4)
EES 113 Paleontologic Evidence for Earth Evolution: Life and Climate in the Rock Record (3)
EES 131 Introduction to Rocks and Minerals (4)
EES 213 Sedimentology and Stratigraphy (3)
EES 223 Structural Geology (3)
EES 373 Geochemical Thermodynamics (3)
EES 301 Introduction to Geophysics (3)
EES 302 Solid Earth Geophysics (3) Minerals (3)
EES 122 Introduction to Plate Tectonics (3), or
EES 326 Geologic Evolution of North America (3)
EES 291 Earth and Environmental Science Research

approved professional electives (12 credit hours)
Courses approved to fulfill this requirement should form a coherent package supporting the professional objectives of the student. Examples of coherent groups of courses are given below. Other courses may be used to fulfill this requirement subject to the approval of the undergraduate adviser.

Emphasis on Environmental Geophysics
EES 376 Geochemistry of Natural Waters
EES 306 Geophysical Field Techniques
EES 309 Environmental Magnetism
EES 316 Hydrogeology
EES 341 Field Geology
EES 307 Case Studies in Engineering Geology

Emphasis on Solid Earth Geophysics
EES 334 Petrology of the Crust and Mantle
EES 374 Isotope Geochemistry and Geochronology
EES 405 Paleomagnetism
*Additional mathematics and physics courses.

Emphasis on Geophysical Signal Processing
EES 308 Seismic Data Processing
EES 407 Seismology
and either
ECE 81 Principles of Electrical Engineering
ECE 108 Signals and Systems
ECE 343 Digital Signal Processing, or
Phy 190 Electronics

Phy 260 Laboratory techniques

*The following 4 mathematics and physics courses are recommended for the solid earth geophysics and tectonophysics areas of emphasis.

Math 208 Complex variables
Math 320 Ordinary Differential Equations
Math 323 Methods of Applied Analysis II
Phy 216 Classical Mechanics II

German

See listings under Modern Foreign Languages.

Government

Professors. Richard K. Matthews, Ph.D. (Toronto); chairperson; Donald D. Barry, Ph.D. (Syracuse), University Professor; Frank T. Colon, Ph.D. (Pittsburgh); Edward P. Morgan, Ph.D. (Brandeis); Laura Katz Olson, Ph.D. (Colorado); Howard R. Whitcomb, Ph.D. (S.U.N.Y. at Albany).

Associate professors. Albert H. Wurth Jr., Ph.D. (North Carolina); Frank L. Davis, Ph.D. (North Carolina); Hannah Stewart-Gambino, Ph.D. (Duke).


The major in government 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 American institutions and political 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 adviser, develop a major program that in their judgment will more adequately fulfill those needs.

The faculty adviser to the student majoring in the government department 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 students, and may suggest courses in other disciplines, language courses, and courses in research techniques that may be of
A variety of experiential opportunities are available to undergraduates majoring in government. The department, for example, offers a Community Politics Internship every semester that includes opportunities for internship placements in 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.

Completion of the government 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 chairman.

Math. 12, Basic Statistics, is highly recommended for students contemplating a major in this department.

**Major Requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>Govt 1</td>
<td>American Political System (3)</td>
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<tr>
<td>Govt 3</td>
<td>Comparative Politics (3)</td>
</tr>
<tr>
<td>Govt 100</td>
<td>Introduction to Political Thought (3)</td>
</tr>
<tr>
<td>Govt 101</td>
<td>Ancient Political Heritage (3)</td>
</tr>
<tr>
<td>Govt 102</td>
<td>Modern Political Heritage (3)</td>
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</tbody>
</table>

**Electives**

Eight elective courses with at least two courses from each of the following two fields:

**American politics, public law and interdisciplinary**

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>Govt 111</td>
<td>The Politics of the Environment (3)</td>
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<tr>
<td>Govt 115</td>
<td>Technology As Politics (3)</td>
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<td>Govt 174</td>
<td>Political Parties and Elections (3)</td>
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<td>Govt 177</td>
<td>Urban Politics (3)</td>
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<tr>
<td>Govt 179</td>
<td>The Politics of Women (3)</td>
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<tr>
<td>Govt 302</td>
<td>Comparative State Politics (3)</td>
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<td>Govt 306</td>
<td>Public Policy Process (3)</td>
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<td>Govt 317</td>
<td>The American Presidency (3)</td>
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<tr>
<td>Govt 327</td>
<td>Socialization and the Political System (3)</td>
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<tr>
<td>Govt 329</td>
<td>Propaganda and American Politics (3)</td>
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<tr>
<td>Govt 330</td>
<td>Politics of the 1960's (3)</td>
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<tr>
<td>Govt 331</td>
<td>Community Politics Internship (3)</td>
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<td>Govt 333</td>
<td>The Social Psychology of Politics (3)</td>
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<tr>
<td>Govt 351</td>
<td>Constitutional Law (3)</td>
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<tr>
<td>Govt 352</td>
<td>Civil Rights (3)</td>
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<tr>
<td>Govt 354</td>
<td>Politics of the Administrative Process (3)</td>
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<tr>
<td>Govt 359</td>
<td>U.S. Congress (3)</td>
</tr>
</tbody>
</table>

**Government Minor**

The minor consists of three core courses listed above (Govt 1, Govt 3, and Govt 100 or 101 or 102) plus any two other government courses.

**Public Administration Minor**

The minor consists of Govt 360 plus four other courses chosen in consultation with the adviser for a total of fifteen credit hours.

**Undergraduate Courses**

1. **American Political System (3)** fall-spring
   Constitutional principles; organization and operation of the national government; the party system, citizenship, and civil rights. (SS)

3. **Comparative Politics (3)** fall-spring
   The political systems of foreign countries; approaches to the study of comparative politics. (SS)

100. **Introduction to Political Thought (3)** fall-spring
   Some of the most significant ancient and modern political theorists: Plato, Aristotle, Machiavelli, Hobbes, Marx, and others. Matthews

101. **Ancient Political Heritage (3)**
   Important political thinkers from the pre-Socratics to early, modern political theorists like Machiavelli. Matthews

102. **Modern Political Heritage (3)** fall-spring
   Begins where Govt 101 ends: from early, modern theorists (e.g., Hobbes) up to contemporary thinkers (e.g., Marcuse). Matthews
111. The Politics of the Environment (3)
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)

115. Technology as Politics (3)
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. Wurth. (ND)

125. (IR 125) International Political Economy (3)
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)

132. (Eco., Hist., I.R.) An Introduction to Canada (3)
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)

174. Political Parties and Elections (3)
Organization, functions, and behavior of parties in the United States; voting behavior, campaigns, and elections. Colon. (ND)

177. Urban Politics (3)
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)

179. (WS 179) The Politics of Women (3)
Major social and political issues relating to the role of women in American society. Study of other countries will be included for comparative analysis. Olson. (SS)

For Advanced Undergraduates and Graduate Students

301. Current Political Controversies (3)
Selected topical policy issues and alternative approaches to understanding them. Including problems facing the current President, controversies in Eastern Europe, reproductive technologies, and crises in the American political economy. (ND)

302. Comparative State Politics (3)
Analysis of major questions relating to the role of the states in the American federal systems and their relationship with the national government. Colon. (ND)

306. Public Policy Process (3)
Power relations and their impacts on selected public policy issues, specifically taxation, housing, environment, poverty, energy, the military, and health. Olson. (ND)

313. Teaching Government (3)
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. (ND)

314. Workshop in Teaching Government (3)
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 Govt 313 when courses are offered together. (ND)

317. The American Presidency (3)
Role of the executive in the American political process. Includes an analysis of the historical development, selection process, and scope of executive power. Prerequisite: Govt 1. Olson. (SS)

318. Seminar in Post Soviet Politics (3)
Analysis of selected issues in the politics of the former USSR. Prerequisites: Government 361 or consent of the instructor. Barry. (SS)

321. Research in Political Science (3)
Models in the explanation of political phenomena, appropriateness of measurement techniques; construction of research designs; rationale and application of statistical analyses; practical and political considerations in the use of opinion polls. Prerequisite: Consent of the instructor. Davis (ND)

322. Politics of Developing Nations (3)
Theories of political development in non-Western areas; modernization and nation building. Field studies and methods; contributions of related disciplines such as sociology and psychology. Prerequisite: Govt 3. Stewart- Gambino (ND)

327. Socialization and the Political System (3)
The social ideological and economic foundations of American politics. Emphasis on supporting institutions—family, schools, and workplace—and processes that foster political attitudes and behavioral patterns. Morgan (ND)

329. Propaganda and American Politics (3)
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)

330. Politics of the 1960's (3)
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 antiwar movement, the counterculture, women's and ecology movements. Prerequisite: junior standing. Morgan (SS)

331. Community Politics Internship (3)
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 the department chairperson. (ND)

333. (SSP 333) The Social Psychology of Politics (3)
Political behavior viewed from a psychological and social psychological perspective. Rosenwein (SS)

335. Latin American Political Systems (3)
The effects on Latin American cultures and political systems of the Spanish colonial period; democratic, authoritarian, and revolutionary paths to contemporary development; and political prospects for the future are some of the major themes discussed. Prerequisite: Govt 3. Stewart-Gambino (ND)

336. U.S. Foreign Policy and Latin America (3)
United States' historical relationship with Latin America. Topics of particular salience to current U.S.-Latin America relations, and topics of current relevance. Stewart-Gambino (ND)

337. Religion and Politics in Latin America (3)
Major indigenous religious structures, the prominent role of the Catholic Church in Latin America, and the recent implosion of Protestant/Pentecostal sects. Stewart-Gambino (ND)

351. Constitutional Law (3) fall
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. Whitcomb (ND)

352. Civil Rights (3) spring
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. Whitcomb, (ND)

354. Politics of the Administrative Process (3)
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)

359. U.S. Congress (3)
The origins and development of Congress, formal and informal power of legislation and oversight. Party leadership and committees, House and Senate differences, and Congressional relations with the President, the bureaucracy and the Supreme Court. Prerequisite: Govt 1. Davis. (SS)

360. Public Administration (3)
The nature of administration; problems of organization and management; public personnel policies; budgeting and budgetary system; forms of administrative responsibility. Colon. (SS)

361. Soviet and Post-Soviet Politics (3)
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)

364. Issues in Contemporary Political Philosophy (3)
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 the department chairperson. Matthews (ND)

367. American Political Thought (3)
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. (ND)

368. Political Economy (3)
Relationship of democratic politics to government and market, and of 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. Group
mobilization and conflict, non-decisions, and symbolic action. Wurth. (ND)

371. Readings (1-3)
Readings in political science assigned to properly qualified students in consideration of their special interest in particular political institutions and practices. Prerequisite: consent of the departmental chairperson. (ND)

372. Readings (1-3)
Continuation of Govt 371. Prerequisite: consent of the department chairperson. (ND)

381, 382. Special Topics (1-3)
A seminar on a topic of special interest in a particular political institution process, or policy. Prerequisite: consent of the department chairperson. (ND)

For Graduate Students
The department of government 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 government is a thirty-credit-hour program that can be accomplished in twelve months by full-time students. A comprehensive examination is required. The student may take twenty-four hours of course work and six hours of thesis or may take all thirty credit hours in course work. A graduate-level course in research methods is 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 a final degree preparatory for teaching in junior and community colleges or research positions in governmental, institutional or industrial settings.

Graduate Courses
405. The Budgetary Process (3)
The public budgetary process: competition among interest groups, policy outcomes, intergovernmental relations, and consequences for policy implementation. Davis

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. Whitcomb

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

413. Modern Political Philosophy (3)
A study of selected modern political philosophers and their continuing effect on politics and political philosophy. Matthews

415. State and Local Government (3)
Comparative state government, urban politics, intergovernmental relations, regional and local government. Colon

416. American Environmental Policy (3)
Formation, implementation and impact of environmental policies in the U.S. An examination of the scope of environmental problems, the development of environmental policy as an issue, the role of interest groups and public opinion, the policy-making process, and the various approaches to implementing environmental policy. Special attention to current issues and administrative approaches and to the distinctive character of environmental protection as a political issue. Wurth

419. Theoretical Issues in American Politics (3)
American contributions to main currents in political philosophy from colonial times to present. Matthews

421. Research Methods (3)
Research approaches, design techniques, statistical and non-statistical analysis, and computer applications. Davis

431. Public Management (3)
The study of bureaucracy and problems of public and nonprofit organization and management; executive leadership; personnel management systems and regulatory administration. Colon

432. Public Policy Process (3)
Impacts of power relationships on selected public policy areas such as the military, agriculture, housing, environmental, energy, poverty, health, and taxation. May be repeated for credit. Olson

434. Internship (3)
Internship in private or public agency. May be repeated for credit.

451. Comparative Politics (3)
Theory and concepts in comparative politics. Analysis of applications in studies of Western and non-Western political systems.
463. Methods of Urban Policy Analysis (3)
Analysis of selected topics in urban or state/local policy. Applied research projects include computer-based statistical analysis. Prerequisite: Govt 421 or consent of the department chairperson. Morgan

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 chairperson.

481. 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.

482. Special Topics (1-3)
Continuation of Govt 481.

Greek
See listings under Classics.

Hebrew
Modern Hebrew is taught in the Department of Modern Foreign Languages. Biblical Hebrew is taught in the Department of Religion Studies.

History

Professors. Roger D. Simon, Ph.D. (Wisconsin), 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); William G. Shade, Ph.D. (Wayne State); Jean R. Soderlund, Ph.D. (Temple).

Associate professors. Stephen H. Cutcliffe, Ph.D. (Lehigh), History and STS; John K. Smith, Ph.D. (Delaware).

Assistant professors. Gail A. Cooper, Ph.D. (U.C., Santa Barbara); John Pettigrew, Ph.D. (Wisconsin); Patricia Turner, Ph.D. (Michigan).

Adjunct professors. Arthur P. Dudden, Ph.D. (Michigan); Joseph A. Dowling, Ph.D. (N.Y.U.), Distinguished Professor Emeritus; Curtis Keim, Ph.D. (Indiana); Winfred Kohls, Ph.D. (Berkeley).


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.

To assure diversity and breadth, majors are asked to take courses in three cultural areas. The writing intensive requirement must be fulfilled by a course in the History department.

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 project. 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. Students planning to pursue this option should take History 202 in the spring of their junior year. Honors students may plan special programs, including more in-depth study of two cultural areas rather than three.

Department Major Requirements
A history major consists of 33 hours; normally 11 courses.
History 11, 12 Survey of European History I and II.
Maximum of nine additional hours in courses below the 100 level, including any Advanced Placement credit.
History 201 or 202. (students planning to pursue independent research are strongly urged to take History 202).
Minimum of 12 additional hours of courses at the 200 or 300 level.
At least one course from each of the groups listed below:

GROUP A COURSES
GROUP B COURSES

GROUP C COURSES
Hist 5, 31, 49, 50, 75, 171, 265, 266, 368.

Hist 300, 301, 371, 372, 391, 392, or provisional courses will be placed in one of the above groups in accordance with their contents and emphases.

History majors are encouraged to choose electives from among economics, English and American literature, government, international relations, philosophy, psychology, religion studies, and sociology. Students intending to do graduate work should acquire a reading knowledge of at least one foreign language, choosing languages appropriate to their area of concentration.

Minor Programs
A student may establish a minor program in history that covers either a geographical, topical, or chronological interest (American, European, technological and medical, or twentieth century history, to mention a few possibilities). 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. The minor totals at least fifteen hours and conforms to the following pattern:
* six hours in courses numbered below 100
* maximum of six hours in 100 level courses
* minimum of three hours in courses numbered above 200

Undergraduate Courses in History
Petitions are required for Freshmen to take 100-level or higher courses, and for Sophomores to take 200-level or higher courses.

5. (AAS 5) African Civilizations (3)
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

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

9. Survey of American History I (3) fall
Social, economic, cultural and political institutions through Reconstruction, emphasizing their effects on public policy and culture. SS. Soderlund

10. Survey of American History II (3) spring
American culture, politics, and society from the late nineteenth century to the present, emphasizing the impact of industrialization. SS. Smith, Pettegrew

11. Survey of European History I (3) 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

12. Survey of European History II (3) spring
Europe from the seventeenth century to the late twentieth. Development of the state system and cultural life during the ancien régime; the impact of the French and industrial revolutions; nationalism and liberalism in the nineteenth century; the two world wars and the end of European supremacy. Hu. Turner

15. English History (3) fall

16. English History (3) spring
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

21. (Class 21) Greek History (3) fall
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

22. (Class 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. SS. Phillips

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. SS. Cooper

49. History of Latin America (3) fall
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

50. History of Latin America (3) spring
Continuation of Hist 49. The development of the Latin American nations in the nineteenth and twentieth centuries. SS. Saeger

75. (MFL 75, Asia 75) Chinese Civilization (3)
Traditional Chinese customs, beliefs, values and institutions and their influence outside China. Thought, literature and the arts in the imperial age. Hu. Pankenier

107. Technology and World History (3)
Development of technology and its relationship to political, economic, military and cultural aspects of world civilization from pyramids to the present. SS. Smith

111. Engineering in the Modern World (3)
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

120. Revolutionary America (3) spring
American political, economic and cultural development from the mid-eighteenth century through the adoption of the Federal Constitution. SS. Soderlund

124. (WS 124) Women in America (3)
Roles of women in American society from colonial to present times: attitudes toward women, female sexuality, women's work, and feminism. SS. Cooper, Soderlund

129. (AAS 129) Black Political Thought in America (3)
Examination of black political thought, leadership and movements for social justice in the United States from 1880 to 1968. The lives, ideas and programs of major black leaders: Booker T. Washington, W.E.B. DuBois, Marcus Garvey, Malcolm X, and Martin Luther King, Jr. SS. Scott

130. (AAS 130) African American History to 1865 (3) fall
Blacks in North America and the West Indies from the first importation of Africans until the end of the Civil War. Topics include: West Africans origins, slave trade, variant slave systems, black culture, free blacks, manumission movements, proselytism ideology, and blacks during the Civil War. SS. Soderlund

131. (AAS 131) African American History Since 1865 (3) spring
The failure of Reconstruction, sharecropping, Jim Crowism, segregation, lynching, urban migration, the Harlem Renaissance, the New Deal, the Civil Rights movement, and affirmative action. SS. Scott

132. (Eco, Govt, IR) An Introduction to Canada (3)
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.

135. United States, 1789-1840 (3)
The American political system from the Constitution through Jacksonianism. Special emphasis upon the first and second party systems and the democratization of American political culture. SS. Shade

136. United States, 1840-1877 (3)
Civil War and Reconstruction, emphasizing the causes of the Civil War, its impact upon American society and politics, and problems of postwar reconstruction. SS. Shade

137. United States, 1877-1920 (3)
Political, economic and social responses to industrial America. The rise of the Populist and Progressive movements, coming of World War I, and postwar developments. HU. Shade

138. United States, 1920-1945 (3)
World War I and its legacy: prosperity, crash and the coming of the New Deal. The rise of fascism and World War II. SS. Pettegrew

139. United States, 1945 to Present (3)
Problems of post-World War II America emphasizing the Cold War and "McCarthyism", Korea, Vietnam and the rise of neo-Conservatism. Analysis of political, social and economic events from Truman to Reagan. SS. Pettegrew

145. (STS 145) Introduction To the History of Science (3)
The history of modern science, primarily physical and biological, with emphasis on the development of major theoretical models since the seventeenth century. SS. Goldman

149. The Barbarian West (3) fall

150. Medieval Civilization (3) spring
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.

152. (Ciss 152/WS 152) Women in Antiquity (3)
Interdisciplinary study of women in Greece and Rome. Literary, archaeological and historical evidence and approaches. Cross-cultural material. SS. Phillips

154. (Rel 154) The Holocaust: History and Meaning (4) spring
For Advanced Undergraduates And Graduate Students

201. Historical Perspectives (3) spring
Methodologies and interpretations of Western historians from ancient times to the present. Hu. Baylor

202. Introduction to Historical Research (3) spring
An introduction to historical interpretation, research design, and methodology. Students will study an historical topic or topics through secondary and primary sources. Honors candidates will apply this knowledge to a design of their thesis project. Required of all students planning to pursue an honors thesis. Permission of Department chairman required. SS.

203. Public History in America (3) fall
An examination of the public role of history in American life. The origins of museums, historical societies, archives and historic preservation with emphasis on the various uses of history by different segments of society. SS. Bastoni

214. (Clss 214) Age of Caesar and Christ (3) 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. SS. Phillips

215. (Clss 215) Decline and Fall of the Roman Empire (3)
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

220. (Clss. 220) Golden Age of Greek Democracy
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

243. English History, 1471-1660 (3) fall
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

244. English History 1660-1789 (3) spring
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

245. Victorian Britain (3) fall
Development of democracy, liberalism, religious ferment, industrialization, class conflict, socialism, and empire in Victorian Britain. Hu. Duffy

246. Great Britain in the 20th Century (3) spring
Effects of world wars, loss of great power status, economic decline, social conflict, welfare state, modern political parties, Irish problem on 20th century Britain. Hu. Duffy

251. France to 1789 (3) Fall
The political development of the French state from the formation of medieval fiefs to the abolition of absolute monarchy with the coming of the French Revolution. The transition from feudalism to mercantile capitalism, the French Renaissance and Enlightenment, and other social and cultural changes which shaped medieval and early modern French Society. SS. Turner

252. France Since 1789 (3) Spring
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

253. (WS 253) Women in European History, 1500-Present (3)
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. SS. Turner

259. (MFL 259) Cultural History of Medieval Russia

261. Russia to 1855 (3) fall
Emergence of Russian autocracy; impact of the Mongol invasions; Westernization and transformation of society and culture, economic development toward emancipation of the serfs. Hu. Kohls

262. Russia Since 1855 (3) spring
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. Kohls

263. Early Modern Germany, 1500-1850 (3) fall
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

264. Modern Germany, 1850 to Present (3) fall
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

265. Mexico and Central America (3) spring
Emphasis on Mexico and Guatemala from the era of the Aztec through the wars of independence to the twentieth century revolutions. SS. Saeger

266. Argentina, Brazil and Chile (3)
Eighteenth-century Spanish imperial readjustments, independence, the emergence of new societies, twentieth-century extremist movements, and the problems of developing nations. SS. Saeger

271. (AAS 271) United States and Africa (3)
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 the shaping of modern Africa, Pan-African relations; influence of African Americans on US policies toward Africa. SS. Scott

307. History of American Industrial Technology (3)
Origin and evolution of American technology and industry from the nineteenth century to the present. Investigates dynamics of major industries in national and international contexts. SS. Smith

310. American Military History (3) spring
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. SS. Saeger

315. American Environmental History (3)
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. Clute

319. Colonial America (3) fall
Founding and growth of colonies in North America through circa 1750. Attention will be paid to motives behind European expansion as well as to developments in the colonies. SS. Soderlund

325. (SSP 325, WS 325) History of Sexuality and the Family in the U.S. (3)
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. Shade, Soderlund
### Description of Courses

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
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<tbody>
<tr>
<td>326.</td>
<td>(SSP 326, WS 326) Social Class in American</td>
<td>Emphasis on the nineteenth and twentieth century, focusing on: emergence</td>
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<tr>
<td></td>
<td>History (3)</td>
<td>of a white-collar middle class; condition and treatment of the poor and</td>
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<td>growth of welfare state; conditions of industrial workers, struggle to</td>
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<td>organize unions and their later decline; indicators of social status and</td>
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<td>exclusion among the rich; changing distribution of income and wealth over</td>
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<td>time and extent of social mobility. SS. Simon</td>
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<td>327.</td>
<td>American Intellectual History (3)</td>
<td>Development of political, social and religious ideas in America from the</td>
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<td>colonial period to the Civil War. Hu. Pettegrew</td>
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<td>328.</td>
<td>American Intellectual History (3)</td>
<td>Economic, political and religious thought in industrial America, 1860 to</td>
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<td>present. Hu. Pettegrew</td>
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<td>333.</td>
<td>American Urban History to 1880 (3)</td>
<td>Planning and design of colonial and frontier cities. Impact of transportation</td>
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<td>innovations and industrialization, emergence of a national system of cities.</td>
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<td>Internal problems of early industrial cities: housing, transportation,</td>
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<td>public health, crime, social mobility. SS. Simon</td>
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<td>334.</td>
<td>American Urban History, 1880 to Present (3)</td>
<td>Physical expansion of the industrial city and its relationship to current</td>
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<td>urban problems. Suburbanization, development of the central business</td>
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<td>district, reforms in housing and public health, rise of ghettos, emergence</td>
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<td>of the city planning profession and the idea of &quot;new town,&quot; impact of the</td>
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<td>New Deal and &quot;urban renewal.&quot; SS. Simon</td>
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<td>338.</td>
<td>Psychohistory (3)</td>
<td>Uses of psychology in history and biography; exploration of problems of</td>
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<td>methodology, verification of evidence, conceptual frameworks and theories</td>
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<td>of personality; potentialities and limitations of psychological investigation</td>
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<td>as an historical technique. SS. Dowling</td>
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<td>335.</td>
<td>(Rel 355) European Cultural History I (3)</td>
<td>Major developments in European culture from the late Middle Ages through</td>
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<td>the 17th century. Late scholasticism, humanism and the Renaissance,</td>
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<td>varieties of Protestantism, origins of modern science. Hu. Baylor</td>
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<td>356.</td>
<td>European Cultural History II (3)</td>
<td>Transformation of European culture from the 18th century to the present.</td>
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<td>The Enlightenment, cultural impact of the French and industrial revolutions,</td>
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<td>romanticism and ideologies of the 19th century, contemporary European</td>
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<td>thought. Hu. Turner</td>
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<td>357.</td>
<td>English Constitutional and Legal History to 1783</td>
<td>Origins and development of government, administration and law from Anglo-</td>
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<td>(3) spring</td>
<td>Saxon times to 1783, emphasizing common-law institutions, practices and</td>
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<td>procedures. SS. Duffy</td>
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<td>360.</td>
<td>American Constitutional and Legal History (3)</td>
<td>Adoption of the federal constitution and its modification and expansion:</td>
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<td>Anglo-American legal tradition and its transformation. SS. Pettegrew</td>
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<td>361.</td>
<td>(Arch 361) Evolution of Highrise Building</td>
<td>The new materials iron and concrete led to new ways of thinking about</td>
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<td>Construction (3)</td>
<td>building. The Industrial Revolution initiated the development of our modern</td>
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<td>culture of building and our current urban society. Hu. Peters</td>
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<td>363.</td>
<td>(Arch 363) Evolution of Long-Span Bridge Building</td>
<td>New materials, forms of education and technology contributed to advance</td>
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<td>(3)</td>
<td>structural understanding. Specialization and the rise of technological</td>
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<td>thinking led to new bridge types and increasing span size. Hu. Peters</td>
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<td>365.</td>
<td>(Arch 365) Evolution of the Modern Building</td>
<td>The criteria of trade--time and money--entered the world of building in the</td>
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<td>Process (3)</td>
<td>19th century. The unplanned interlude between the design and the inauguration</td>
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<td>of a building became a new professional field: the building process. Hu.</td>
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<td>Peters</td>
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<td>368.</td>
<td>Seminar in Latin American History (3)</td>
<td>Readings and individual investigation of selected topics. SS. Saeger</td>
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<td>371.</td>
<td>Special Topics in History (1-3)</td>
<td>Intensive study in an area of history not adequately covered in currently</td>
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<td>listed offerings. The course may be administered as a reading program or</td>
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<td>otherwise as may seem best to meet the needs of students of unusual ability</td>
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<td>and adequate preparation. Prerequisite: consent of the department chairman.</td>
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<td>372.</td>
<td>Special Topics in History (1-3)</td>
<td>Continuation of History 371. Prerequisite: consent of the department</td>
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<td>chairperson. (ND)</td>
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<tr>
<td>391.</td>
<td>Honors Thesis in History (3)</td>
<td>Opportunity for undergraduate majors in History or American Studies to</td>
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<td>pursue an extended project for senior honors. (ND)</td>
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<tr>
<td>392.</td>
<td>Honors Thesis in History (3)</td>
<td>Continuation of History 391. (ND)</td>
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</table>
For Graduate Students

Lehigh University has been granting advance 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, Science, and Medicine. The department works closely with the Lawrence Henry Gipson Institute for Eighteenth Century Studies which sponsors yearly symposia 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 twenty-seven 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 build on work presented in a graduate research seminar in the program. A student seeking to present a lengthier master's thesis may do so with twenty-four hours of approved course work. Candidates continuing toward a doctorate should select Plan I. Candidates declaring Plan II take thirty hours of approved course work and pass examinations in two fields chosen from American, British, European and Latin American history, and history of science and technology. Candidates in either plan are required to maintain a 3.0 average in all graduate work and to take at least one research seminar.

Doctor of Philosophy

Candidates for the doctor of philosophy in history must maintain a 3.25 history average and a 3.0 over-all average on all graduate work taken at Lehigh or elsewhere. Students entering with a master's degree take a qualifying examination before beginning their second semester at Lehigh. During the second semester, doctoral students select two major and two minor fields in which to take comprehensive written and oral examinations. The candidate will also choose a dissertation field and a dissertation advisor who will chair the special committee which 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 outside the department relevant to the candidate's major field. The candidate will then, in consultation with the members of the committee, prepare for the examination in those fields. The special committee may compel additional work beyond the minimum requirements given above. No professor may direct more than one field, but the direction of a field may involve two professors. An original dissertation is required and may be written only in a major field and must be successfully defended to the examining committee.

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; Medieval and Early Modern Europe; Modern Europe; Latin America; Science; Medicine, Science, Technology and Society studies.

Language requirements. The qualifying examination in one language must be passed before beginning course work beyond the master's degree in order that the language may be used in doctoral course work. The candidate's special committee, appointed by the chairman of the department, will designate any additional languages for the student, if needed. Languages normally chosen are French, Spanish, Italian, German or Russian. Graduate-level competence in statistical methods and computer application are acceptable as replacement for a foreign language. All graduate majors take Hist 401 and either 404 or 405. All Ph.D. candidates must take 18 hours of directed readings and one research seminar beyond the M.A. More detailed regulations are given in the Handbook for Graduate Work in History, available in the history department office.

401. Methods in Historical Research (3) fall
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. Required of all graduate students in history. Shade

404. Historiography: Europe (3)
The approach, methods and interpretations of the leading historians of Europe.

405. Historiography: America (3)
The approach, methods and interpretations of the leading historians of America.

407. Seminar in the History of American Industrial Technology (3)
Origin and Evolution of American technology and industry from the nineteenth century to the present. Investigates
dynamics of major industries in national and international context. Not open to students who have taken Hist 307. Smith

415. **Introduction to the History of Technology in Western Civilization (3)**
Analysis and historiography of the history of technology. Smith

440. **Readings in Colonial American History (3)**
Study in small groups under the guidance of a faculty member of the literature of the seventeenth and eighteenth centuries. May be repeated for credit with the permission of the department chairman.

441. **Readings in Nineteenth Century American History (3)**
Study in small groups under the guidance of a faculty member of the literature of the nineteenth century. May be repeated for credit with the permission of the department chairman.

442. **Readings in Twentieth Century American History (3)**
Study in small groups under the guidance of a faculty member of the literature of the twentieth century. May be repeated for credit with the permission of the department chairman.

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 department chairman.

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 department chairman.

445. **Readings in the History of Science (3)**
Study in small groups under the guidance of a faculty member of the history of science. May be repeated for credit with permission of the department chairman.

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 department chairman.

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 department chairman.

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 chairman.

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 chairman.

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 chairman.

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 chairman.

457. **Research in European History (3)**
An intensive research seminar on phase of European history. May be repeated for credit with permission of the department chairman.

471. **Special Topics in History (1-3)**
Individual study under direction of a faculty member of a topic in history. May be repeated for credit.

472. **Special Topics in History (1-3)**
Individual study under 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); Mikel P. Groover, Ph.D. (Lehigh); Louis A. Martín-Vega, Ph.D. (Univ. of Florida) chairperson; Nicholas G. Odrey, Ph.D. (Penn State); Emory W. Zimmers, Jr., Ph.D. (Lehigh).

**Associate professors.** Laura I. Burke, Ph.D. (California-Berkeley); Louis J. Plebani, Ph.D. (Lehigh). G. Sathiyanarayanan, Ph.D. (Michigan Tech); Robert H. Storer, Ph.D. (Georgia Tech); Gregory L. Tonkay, Ph.D. (Penn State); George L. Wilson, Ph.D. (Penn State); Szu-Yung David Wu, Ph.D. (Penn State).

**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.

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 IE's, 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. 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. The EML is a new laboratory currently being developed as a teaching and research facility. Technologies include 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 team situations. A full-scale manual assembly line is available for study.

Considerable use is made of university computer facilities in IE coursework, and an IE/Computing Center workstation-laboratory containing fifteen RISC 6000 engineering 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 program. 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 305: Simulation (3)
- 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 303: Macroprocessing of Materials (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 344: Materials Joining Methods (3)
Mat 345 Nondestructive Evaluation (3)

**Operations Research.** Students specializing in this area should select 300 level courses from the following list:

- IE 305 Simulation (3)
- IE 316 Advanced Operations Research (3)
- IE 332 Quality Control (3)
- IE 339 Queuing Theory (3)
- CSc 327 Artificial Intelligence Applications (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 Applications (3)
- CSc 340 Design and Analysis of Algorithms (3)
- CSc 368 Artificial Intelligence Programming (3)
- ECE 319 Digital 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 I&MSE curriculum.

**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).

**Master of Business Administration.** (MBA).

Undergraduates in I&MSE may choose electives that satisfy prerequisite requirements in the master's degree program in business administration, thus permitting them to complete the MBA in one additional year beyond the four year BS program. The MBA prerequisite courses, some of which are included in the regular I&MSE curriculum, are listed below:

- Acct 151 Introduction to Financial Accounting (3)
- Acct 152 Introduction to Managerial Accounting (3)
- Acct 324 Cost Accounting (3)
- Eco 119 Intermediate Microeconomic Analysis (3)
- Eco 229 Money and Banking (3)
- IE 121 Applied Engineering Statistics (3)
- IE 221 Operations Research - Probabilistic Models (3)
- IE 222 Operations Research - Deterministic Models (3)
- Law 201 Legal Environment of Business (3)

Acct 151 can be substituted for Acct 108, which is a required course in the regular BSIE curriculum; and IE 121, IE 221, and IE 222 are required courses in the BSIE curriculum. The other courses in the prerequisite list can be rostered as either humanities and social sciences or free electives, but some overloading or summer school may be required to complete the entire list within the four year period. A grade of B or better must be attained in each course for it to be credited toward the MBA degree. Upon completion of the four year BSIE curriculum, and assuming the student is admitted to the Graduate School, the additional 39 credit hours of MBA coursework can be completed within two regular semesters and two summer sessions. Students who do not take Acct 152 and Acct 324 as undergraduates will be required to take Acct 413 as part of their MBA coursework. Students who do not take Eco 119 and Eco 229 as undergraduates will be required to take Eco 409 as part of their MBA coursework.
Major Requirements

Freshman Year: See page 45.

Sophomore Year, First Semester: (16 credit hours)
- IE 111: Engineering Probability and Statistics (3)
- IE 112: Computer Graphics (1)
- Math 23: Analytic Geometry & Calculus III (4)
- Phys 21, 22: Introductory Physics II and Laboratory (5)
- Mat 33: Engineering Materials and Processes (3)

Sophomore Year, Second Semester: (16 credit hours)
- IE 111: Engineering Probability and Statistics (3)
- IE 112: Computer Graphics (1)
- Math 23: Analytic Geometry & Calculus III (4)
- Phys 21, 22: Introductory Physics II and Laboratory (5)
- Mat 33: Engineering Materials and Processes (3)

Sophomore Year, Second Semester: (16 credit hours)
- IE 121: Applied Engineering Statistics (3)
- IE 122: Software Tools (1)
- IE 124: Engineering Economy and Decision Analysis (3)
- ME 104: Thermodynamics I (3)
- Acct 108: Principles of Microeconomics or Macroeconomics (3)
- Eco 11 or 12: Fundamentals of Accounting (3)

Junior Year, First Semester: (16 credit hours)
- IE 115: Fundamentals of Modern Manufacturing (3)
- IE 116: Manufacturing Laboratory (1)
- IE 221: Operations Research - Probabilistic Models (3)
- Math 205: Linear Methods (3)
- Mech 2: Elementary Engineering Mechanics (3)
- HSS: Humanities/Social Sciences elective (3)

Junior Year, Second Semester: (17 credit hours)
- IE 131: Work Systems and Facilities Planning (3)
- IE 132: Work Systems and Facilities Planning Laboratory (1)
- IE 222: Operations Research - Deterministic Models (3)
- IE 224: Information Systems Analysis and Design (3)
- ECE 81: Principles of Electrical Engineering (4)
- IE elective (3)

Summer
- IE 100: Industrial Employment (0)

Senior Year, First Semester: (18 credit hours)
- IE 251: Production and Inventory Control (3)
- IE elective (3)
- IE elective (3)
- ESE: engineering science elective (3)
- HSS: Humanities/Social Sciences elective (3)
- FE: free elective (3)*

Senior Year, Second Semester: (18 credit hours)
- IE 154: Senior Project (3)
- IE elective (3)
- IE elective (3)
- HSS: Humanities/Social Sciences elective (3)
- HSS: Humanities/Social Sciences elective (3)
- FE: free elective (3)*

Notes:
1. The engineering science elective is chosen
2. Any course can be used as a free elective
3. IE elective courses are chosen from the current offering of 300-level IE courses

Undergraduate Courses

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.

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. (ES2) (ED0)


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. (ES0) (ED1)

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. (ES1) (ED2)

116. Manufacturing Laboratory (1): Fall

Laboratory exercises and experiments in manufacturing processes and systems. Prerequisite: IE 115, either previously or concurrently. (ES0) (ED1)


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. (ES2) (ED0)

122. Software Tools (1): Spring

Introduction to application software tools, including word processing, spreadsheets, and statistical packages. Problems for solution will be drawn from other courses in the sophomore program. Prerequisites: Engr. 1; IE 121, previously or concurrently. (ES0) (ED1)

124. Engineering Economy and Decision Analysis (3): Spring

Economic analysis of engineering projects; interest rate factors, methods of evaluation, depreciation, replacement, break-even analysis, after-tax analysis. Decision-making under uncertainty and risk. Prerequisite: IE 111 or Math 231, either previously or concurrently. (ES1) (ED2)
131. Work Systems and Facilities Planning (3) spring
Techniques of methods analysis, work measurement, and facilities design. Man-machine systems, assembly systems, operations analysis, time study, predetermined time systems, work sampling, incentive systems, plant layout, and materials handling. Prerequisite: IE 121, either previously or concurrently. (ED3)

132. Work Systems and Facilities Planning Laboratory (1) spring
Laboratory exercises and projects in methods analysis, operations analysis, plant layout, and related topics. Prerequisite: IE 131, either previously or concurrently. (ES0) (ED1)

154. Senior Project (3) fall and spring
The use of industrial engineering techniques to solve a major problem in either a manufacturing or service environment. Problems are sufficiently broad to require the design of a system. Consideration of human factors in the system design. Laboratory. Prerequisite: Senior standing in industrial engineering. (ED3)

168. Production Analysis (3) fall and spring
A course for the engineering student not majoring in industrial engineering. Engineering economy; application of quantitative methods to facilities analysis and planning, operations planning and control, work measurement and scheduling, and operating systems analysis. Prerequisites: Math 23. (ES1) (ED2)

For Advanced Undergraduates and Graduate Students

221. Operations Research - Probabilistic Models (3) fall
Probabilistic models in operations research. Topics include queuing theory, probabilistic inventory models, Markov analysis, and simulation, including use of a simulation language. Prerequisite: IE 111 or Math 231. (ES3)

222. Operations Research - Deterministic Models (3) spring
Deterministic models in operations research. Topics include linear programming, integer programming, networks, dynamic programming, and classical optimization. Prerequisite: Math 205. (ES3)

224. Information Systems Analysis and Design (3) spring
An Introduction to the technological as well as methodological aspects of computer information systems. Content of the course stresses basic knowledge in database systems. Topics include database design and evaluation, query languages and software implementation. (ED3)

251. Production and Inventory Control (3) fall
Techniques used in the planning and control of production and inventory systems. Topics include forecasting, inventory models, operations planning, and scheduling. Prerequisite: IE 221, either previously or concurrently, and IE 121, IE 222. (ED3)

305. Simulation (3)
Applications of discrete and continuous simulation techniques in modeling industrial systems. Simulation using a high level simulation language. Design of simulation experiments. Prerequisites: IE 121 and IE 221. (ES2), (ED1)

307. Advanced Systems Analysis and Design (3) spring
Study of advanced techniques and their application in the analysis and design of information systems. Emphasis is placed on tools and techniques used for structured analysis and design, and on prototyping of systems. Prerequisite: IE 224 or equivalent. (ED3)

309. Introduction to Information Systems (3) fall
Study of information systems analysis and design with emphasis on management issues. Interfaces between information systems and databases and data communications systems are examined. Effects of information systems on organizational relationships are considered. Example information system will be designed and implemented. Prerequisite: IE 224 or equivalent. (ED3)

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. (ED3)

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. (ED3)

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. (ED3)

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. (ES2), (ED1)

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. (ES1), (ED2)

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 used by IE undergraduates as an IE 300 level elective. (ES 2), (ED 1)

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. (ES 2), (ED 1)

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. (ES 3)

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. (ES 3)

340. Production Engineering (3) fall
Develop plans of manufacturing for discrete parts. Product design analysis and engineering materials utilization. Economic analysis of process design alternatives. Introduction to mechanization, automation, and flexible manufacturing systems. Term project. Laboratory. Prerequisite: IE 115. (ES 3)

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 networking techniques, and queuing/simulation analysis of network performance. Prerequisite: IE 224 and IE 221 or equivalent. (ES 2), (ED 1)

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. (ES 1), (ED 2)

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. Prerequisite: IE 224 and IE 115 or equivalent. (ED 3)

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. (ES 2), (ED 1)

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. (ED 3)
Graduate Programs
Several programs leading to masters and doctor 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 coursework, (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 the Graduate School section of this catalog as well as in an IE graduate brochure available from the department. In addition, several documents are available from the department which 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.

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 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 masters 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.

405. Special Topics in Industrial Engineering (3)
An intensive study of some field of industrial engineering.

408. (Acct 433) 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 Acct 311 or equivalent.

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.

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. Prerequisite: IE 121 or equivalent.

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.

415. Manufacturing Management (3)
Analysis of the factors entering into the development of manufacturing management philosophy; decision-making process in areas of organization, planning, operation, and control of manufacturing. Influence of the social, technical, and economic environment upon manufacturing management decisions.

416. Dynamic Programming (3)
The principle of optimality and recursive solution structure; multidimensional problems; reduction of dimensionality and approximation; stochastic control; non-serial systems; relationship to calculus of variation; applications. Prerequisite: IE 316 or equivalent.

417. (Mgt 445) 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.

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.

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.

422. Measurement and Inspection Systems (3)

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.

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.

430. (Mgt 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.

431. Operations Research Seminar (3)
Extensive study of selected topics in techniques and models of operations research.

433. Manufacturing Engineering Seminar (3)
Extensive study of selected topics in the research and development of manufacturing engineering techniques.

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.

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.

439. Applications of Stochastic Processes (3)
Introduction to stochastic processes, application in queuing theory and inventory theory. Prerequisites: IE 221 or equivalent.

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.

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 115 or equivalent.

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.

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.

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.

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.

461. Readings (1-3)
Intensive study of some area of industrial engineering which is not covered in general courses.

490. Thesis (1-6)

499. Dissertation (1-15)

Interdisciplinary Technology Courses

See listings under Science, Technology and Society.

International Careers

Alvin Cohen, Ph.D. (Florida), professor of economics and director, International Careers major.

This major in the College of Arts and Science is designed to meet the needs of the student who has decided upon an international business, or political focus for his education. It uses elements of the traditional liberal arts and business school curricula. Among those traditional liberal arts elements are courses in economics, government, history, international relations, and language. With respect to business school offerings, there are courses in accounting, finance, and economics. The major also represents an excellent foundation for MBA graduate study leading to an, a law degree, and graduate programs in the social sciences.

Each student completes the courses in the common core, takes twelve credit hours from offerings in economics, government, history, international relations, and social relations as related to an area of geographical concentration, and twelve credit hours in a functional option. Although not a requirement, students should study the language related to their area of specialization.
**Major Requirements**

Common Core  
*(18 credit hours)*

- Eco 11: Micro Principles (3)  
- Eco 12: Macro Principles (3)  
- Govt 3: Comparative Politics (3) or IR 10 (3)  
- Math 41: or its equivalent (3)  
- Eco 145: or its equivalent (3)  
- Acct 151 or 108: (3)

Geographical Concentrations  
*(12 credit hours from any one of the four areas)*

**Functional Options**

Pick one of the two listed below:

- International Business *(12 credit hours)*
  - Eco 229: Money and Banking (3)  
  - Eco 303: Economic Development (3)  
  - Eco 339: International Trade (3)  
  - Eco 340: International Finance (3)

- Public Administration *(12 credit hours)*
  - Eco 353: Public Finance (3)  
  - IR 353: International Institutions (3)  
  - Govt 322: Politics of Developing Nations (3) or IR 10 (3)  
  - Eco 303: Economic Development (3)  
  - Govt 360: Public Administration (3)

**International Relations**

Professor and Chairperson: Raymond F. Wylie, Ph.D.  
(London-England).  
**Professors.** Rajan Menon, Ph.D. (Illinois); Monroe J.  
Rathbone Professor: Oles M. Smolansky, Ph.D. (Columbia),  
University Professor.  
**Associate professor.** Henri J. Barkey, Ph.D. (Pennsylvania);  
Bruce E. Moon, Ph.D. (Ohio State).  
**Assistant professors.** Chaim D. Kaufmann, Ph.D.  
(Columbia).  
**Emeritus Professors.** Henderson B. Braddock, Ph.D.  
(Washington); Carey B. Joynt, Ph.D. (Clark); Zdenek J.  
Slouka, Ph.D. (Columbia).  

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. In sum, International Relations is not a  
remote abstraction that educated men and women can afford to  
to ignore.

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; theories of foreign policy decision-making; the  
foreign policies of the major powers; international security  
and arms control; regional conflicts; global problems such as  
terrorism, refugee relief, and pollution; international political  
economy; 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. Our majors are encouraged to take  
courses in these disciplines.

The Curriculum: To meet our educational goals, the  
Department of International Relations devised a new  
curriculum to take effect from the 1995-96 academic year. It  
consists of four segments: 1) A lower-level core comprising  
four courses and a one-hour laboratory; 2) An area studies  
core of three courses; 3) An upper-level core of four courses;  
4) A research seminar. This revised curriculum will be  
modified somewhat when the College of Arts and Sciences  
moves to a mixed credit system in the 1996-97 academic year.  
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  
adviced to take Eco. 11 (Principles of Microeconomics) or 12  
(Principles of Macroeconomics) and Math 12 (Basic Statistics)  
to fulfill their College distribution requirements.

Students may also minor in International Relations by  
taking IR 10 and four other courses offered by the  
Department.

Beyond 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 England, Belgium,  
France, and Guatemala.  
Every semester a variety of speakers with expertise on  
various aspects of world affairs visit Lehigh. Together with  
the Center for International Studies, the department arranges  
the annual Cohen International Lecture Series, which has  
featured speakers such as Robert McNamara, Valery Giscard  
d'Estaing, Vaclav Havel, Hans Dietrich Genscher, Kim  
Campbell and Oscar Arias.
The student-run International Relations Club organizes the Model United Nations. Each year, it selects students for Model UN conferences held at Princeton, Harvard, and other universities, and for student conferences at West Point and the US Naval Academy. The department also offers an internship program for students interested in working at Lehigh's Office of Community Relations and International Students/Scholars Office.

**Upon Graduating:** We are often asked about the employment prospects of students who major in International Relations. We take very seriously their questions regarding career planning. 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. Our majors 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**

**Required lower level core (4 courses plus lab)**

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tr>
<td>IR 10</td>
<td>Introduction to World Politics (3)</td>
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<tr>
<td>IR 101</td>
<td>Theories of International Relations (3)</td>
</tr>
<tr>
<td>IR 102</td>
<td>Rise and Decline of Empires (3)</td>
</tr>
<tr>
<td>IR 125</td>
<td>International Political Economy (3)</td>
</tr>
<tr>
<td>IR 110</td>
<td>Laboratory in International Relations (1)</td>
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</tbody>
</table>

**Required area studies core (3 courses from an approved list).** Chosen in consultation with the major adviser. See department for current list of courses.

**Required upper level core (one course from each of four areas)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tr>
<td></td>
<td>Foreign Policy (IR 211)</td>
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<td>Political Economy (IR 221, 222, or 223)</td>
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<td></td>
<td>International Security (IR 232)</td>
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<td></td>
<td>International Institutions (IR 241 or 242)</td>
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</tbody>
</table>

Research seminar (one course at the 300 level)

**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;

(b) complete a 6-credit honors thesis in the senior year.

**Minor in International Relations**

The minor program is designed for undergraduates of any college who wish to acquire a knowledge of international relations in addition to their major. Requirements: IR 10 and four other courses chosen in consultation with the minor adviser.

**Undergraduate Courses**

**IR 9. Current Crises. (1-3)**

Analysis of selected world crises. Focus on current developments in historical context. Emphasis upon policy options and likely outcomes. Different topic each semester. May be repeated for credit. Staff. (SS)

**IR 10. Introduction to World Politics (3)**

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. Staff. (SS)

**IR 33. War and World Politics (3)**

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, Barkey. (SS)

**IR 61. (ASIA 61) East Asian International Relations (3)**

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; Southeast Asia; U.S. and Russian policies; current and future issues. Wylie. (SS)

**IR 71. United States Foreign Policy (3)**

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 upon 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. Moon, Kaufmann. (SS)

**IR 72. The United States in the Global Economy (3)**


**IR 81. Middle East in World Affairs to 1945 (3)**

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 (3)**
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 101. Theories of International Relations (3)
Examination of various theoretical approaches to international relations and their application to historical and contemporary cases. Levels of analysis; balance of power; hegemonic stability theory; cause of war; role of nuclear weapons. Prerequisite: IR 10. Weber, Kaufmann. (SS)

IR 102. Rise and Decline of Empires (3)
An overview of the expansion, over-extension, and collapse of empires. Focus on alternative theories of empires as well as historical cases. Prerequisite: IR 10. Menon. (SS)

IR 100. Laboratory in International Relations (1)
Basic elements of research and writing for international relations majors. Topic selection, search techniques, basic library resources, thesis formulation, canons of evidence, rules of citation. Must be taken concurrently with either IR 101 or IR 102. Staff. (ND)

IR 119. Issues in International Relations (3)
Readings on selected themes in world politics, with theme to change each semester. Prerequisite: IR 101 or IR 102. Staff. (SS)

IR 125. International Political Economy (3)
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; IR 10. Moon, Barkey. (SS)

IR 132. (Eco, Govt, Hist) An Introduction to Canada (3)
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. Staff. (SS)

IR 162. (ASIA 162) China in World Affairs (3)
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 (3)
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, RS 164) Japan’s Response to the West (3)
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 166. The International Relations of Russia and Eastern Europe (3)
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 internation relations of Eastern Europe (including the Balkans). Menon. (SS)

IR 167. Diplomacy of Russia to 1917 (3)
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. Slomansky. (SS)

IR 168. Diplomacy of the USSR, 1917-1991 (3)
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; frictions within the Communist Bloc (Eastern Europe, China); nuclear arms race; striving for detente; activity in the Third World; Gorbachev and collapse. Slomansky. (SS)

IR 177. International Relations of Latin America (3)
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 211. Theories of Foreign Policy (3)
Sources of foreign policy, including economic and domestic structure; the roles of bureaucracies and individual leaders; the impact of beliefs and images; learning from history; psychological explanations. Prerequisites: IR 101 and IR 102. Kaufmann. (SS)
IR 221. Economic Relations of Advanced Industrial Societies (3)
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 222. Political Economy of North-South Relations (3)
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, Menon. (SS)

IR 223. The Political Economy of Newly Industrializing Countries (3)
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 232. The Role of Force in International Relations (3)
Theories of war and international insecurity; arms races; influence of domestic politics and bureaucracies; misperception. Tools of war prevention; deterrence; alliances; collective security; arms control. Nationalism; the nuclear and information revolutions; the changing usefulness of force. Prerequisites: IR 101 and IR 102. Kaufmann, Weber. (SS)

IR 241. International Law (3)
Function of law in international relations. Foundation and structure of international law. Sources of international legal rights and obligations. International law-making and settlement of disputes. Prerequisites: IR 101 and IR 102. Staff. (SS)

IR 242. International Institutions (3)
Role of international institutions in world politics. Origins, interplay and functions of intergovernmental and nongovernmental organizations. Possible role of supranational organizations in replacing or modifying the present state-centered system. Special emphasis given to NATO, the United Nations and the European Community. Prerequisites: IR 101 and IR 102. Weber. (SS)

IR 246. (Jour 246) International Communication (3)
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)

IR 251. The International Relations of Western Europe (3)
Research-oriented seminar on Western Europe's international relations, with heavy emphasis on relations with the United States and recent events: analysis of major political and economic developments since 1945; study of significant changes of the post-Cold War period to ascertain whether relations between the Western Allies can be expected to be conflictual or cooperative. Prerequisites: IR 101 and IR 102. Weber. (SS)

IR 277. Canada-United States Relations (3)
Research-oriented seminar on Canada's relations with the United States, with emphasis on post-1945 period. Substantial research paper on topic of students' own choice required. Wylie. (SS)

IR 306. Seminar in International Relations Theory (3)
Analysis of new trends in international relations theory, selected from: the obsolescence of major war; the resurgence of nationalism; the role of change and continuity, integration and disintegration, conflict and cooperation in international relations. Prerequisites: IR 101 and IR 102. Weber. (SS)

IR 312. Seminar in Psychology and Foreign Policy (3)
Analysis of selected advanced topics in the processes, politics, or psychology of foreign policy decision making. Prerequisite: IR 211, or consent of instructor. Kaufmann (SS)

IR 326. Seminar in International Political Economy (3)
Analysis of selected issues in contemporary international economic relations. A substantial research paper on a topic of the student's own choice is required. Topic varies each year. Prerequisite: IR 125. Moon, Barkey. (SS)

IR 333. Seminar in International Security (3)
Analysis of selected advanced topics in war prevention, strategy, or U.S. defense policy. Prerequisite: IR 232, or consent of instructor. Kaufmann. (SS)

IR 344. Seminar in International Law (3)
Case studies in the dynamics of international regulatory processes. Political, socio-economic, and cultural foundations of the international legal system. Prerequisite: IR 241. Staff. (SS)

IR 364. Seminar in the International Relations of East Asia/Pacific Rim (3)
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 students' own choice is required. Prerequisite: IR 61, 162, 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. Prerequisite: IR 168 or IR 169. Menon, Smolansky. (SS)

IR 371. Readings in International Relations (1-3)
Directed course of readings intended for students with special competence or interest in fields of international relations and fully covered by regular course offerings. May be repeated for credit. Departmental permission required. (SS)

IR 372. Readings in International Relations (1-3)
Continuation of IR 371. Departmental permission required. (SS)

IR 384. Seminar in International Relations of the Middle East (3)
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 81 or IR 82. Smolansky. (SS)

IR 391. Special Topics (1-3)
Intensive study of some aspects of international politics not covered in another course. May be repeated for credit. Departmental permission required. (SS)

IR 392. Special Topics (1-3)
Continuation of IR 391. Departmental permission required. (SS)

IR 395. Internship in International Relations (1-3)
Internship in public or private agency. May be repeated for credit. Departmental permission required. (ND)

Japanese
See Listings under Modern Foreign Languages.

Journalism and Communication

Professor. Sharon M. Friedman, M.A. (Penn State), Iacocca Professor and director of science writing program.
Associate professors. Carole M. Gorney, M.S.J., A.P.R. (Northwestern); Jack Lule, Ph.D. (Georgia) chairperson; 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); Nancy S. Ross, M.A.T. (Cincinnati); William White, M.A. (Ohio State); Dina Wills, Ph.D. (Oregon).

The department of journalism and communication offers major and minor programs in print journalism and science writing as well as a minor program in public relations. It also jointly sponsors an interdisciplinary communication minor with the Communication Studies Program.

The profession of journalism deals with the truthful communication and explanation of facts. It is the purpose of the program in journalism to bring its majors to a point at which they can gather significant information, organize it quickly and communicate it clearly, accurately and objectively. It also aims to bring students to an understanding of the legitimate role of the mass media in society.

The first of these objectives is attained by extensive, professionally oriented practice in the reporting, writing and editing of the news. Emphasis is placed on precision and clarity of expression and sophistication of style.

The second objective is attained by study of the rights and responsibilities of the mass media under the U.S. Constitution. The first of these objectives is attained by extensive, professionally oriented practice in the reporting, writing and editing of the news. It also aims to bring students to an understanding of the legitimate role of the mass media in society.

In the basic journalism program, students take courses in news and feature writing, editing, law and ethics, reporting, and a seminar in mass media. In addition, many students pursue a concentration in at least one of the following areas: American studies, economics, government, history, international relations, languages, literature, philosophy, religion studies, various scientific disciplines, social relations and urban studies. Some journalism students elect to pursue a double major. Others choose a minor or a concentration in one of these fields.

A second major program available to students is the science writing major, which encompasses training in science, environmental and technical writing. Those selecting this major will 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. A minor in science writing is available for those who wish to major in science or engineering and become skilled in science communication techniques.

All science, environmental and technical writing students may enroll in the science writing field research program, which offers a unique opportunity for practical experience in scientific research and science writing.

A public relations minor is available to students interested in a career in such areas as nonprofit, governmental and corporate public relations. The courses offered cover theory, skills and practical application of public relations.

An interdisciplinary minor in communication is offered jointly with the Communication Studies Program 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.

Although most journalism graduates choose some phase of written communication as a career—newspapers, wire services, magazines, broadcasting, public relations, advertising—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.

Those concentrating in science writing can expect to pursue careers in science journalism; in public information or public relations for scientific societies, government agencies, universities or hospitals; in technical writing for industry and government agencies; and in other areas, such as management, administration and teaching, in which science communication skills are highly desirable. The program also prepares students for graduate study in science writing, journalism and other disciplines.

Students who complete the public relations minor will be prepared for both entry-level positions and for management responsibilities that are likely to occur later in the students' careers. Studies in writing, communication and media give minors a grasp of the basics essential for the first job in public relations. An emphasis on planning, programming and management techniques provides the background needed to respond to advancement opportunities in the field.

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.

Suggested math course. Math.12, Basic Statistics, is highly recommended for students contemplating a Journalism or Science Writing Major. While not required, this course should be taken instead of another math course to fulfill the college's distribution requirement, if possible.

### Basic Journalism Major

**required preliminary courses**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jour 1</td>
<td>Brown &amp; White (1)</td>
</tr>
<tr>
<td>Jour 11</td>
<td>News Writing (4)</td>
</tr>
</tbody>
</table>

**required major courses**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jour 2-3</td>
<td>Brown &amp; White (2)*</td>
</tr>
<tr>
<td>Jour 12</td>
<td>Feature Writing (3)</td>
</tr>
<tr>
<td>Govt 177</td>
<td>Urban Politics (3)</td>
</tr>
<tr>
<td>Jour 13</td>
<td>Editing (3)</td>
</tr>
<tr>
<td>Jour 122</td>
<td>Media Ethics and Law (3)</td>
</tr>
<tr>
<td>Jour 315</td>
<td>Advanced Reporting (4)</td>
</tr>
<tr>
<td>Jour 320</td>
<td>Journalism Proseminar (3)</td>
</tr>
<tr>
<td>Jour 361</td>
<td>Internship (3)</td>
</tr>
</tbody>
</table>

plus three of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jour 124</td>
<td>Politics of Science (3)</td>
</tr>
<tr>
<td>Jour 125</td>
<td>Environment, the Public and the Mass Media (3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jour 127</td>
<td>Public Relations Principles (3)</td>
</tr>
<tr>
<td>Comm 130</td>
<td>Public Speaking (3)</td>
</tr>
<tr>
<td>Jour 135</td>
<td>Human Communication (3)</td>
</tr>
<tr>
<td>Jour 141</td>
<td>Photojournalism (3)</td>
</tr>
<tr>
<td>Comm 143</td>
<td>Persuasion and Influence (3)</td>
</tr>
<tr>
<td>Comm 144</td>
<td>Effective Interviewing (3)</td>
</tr>
<tr>
<td>Jour 214</td>
<td>Reporting of Public Affairs (4)</td>
</tr>
<tr>
<td>Jour 215</td>
<td>Publication Design (3)</td>
</tr>
<tr>
<td>Jour 246</td>
<td>International Communication (3)</td>
</tr>
<tr>
<td>Jour 240</td>
<td>Writing for Broadcasting (3)</td>
</tr>
<tr>
<td>Jour 327</td>
<td>Mass Communication &amp; Society (3)</td>
</tr>
<tr>
<td>Comm 331</td>
<td>Business and Professional Speaking (3)</td>
</tr>
</tbody>
</table>

(Not all elective courses are taught every year.)

Thirty-eight credits are required.

*Note: A minimum of three semesters is required on The Brown and White. The course involves work on the student's newspaper. One of these required semesters must be taken during the student's junior year, and one must be taken during the senior year.

**Dual major and recommended electives.** Journalism majors are encouraged to declare dual majors in journalism and another field, such as one of those discussed under concentrations above. In-depth knowledge of a specialty area is considered an asset to a journalism career. Those not desiring to declare a dual major should consider either declaring a minor in one of these fields or concentrating their elective courses in one or two of these areas. Dual majors, minors and concentration areas should be chosen in consultation with the major adviser.
### Journalism/Science Writing Major

**required preliminary courses**

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jour 1</td>
<td>Brown &amp; White (1)</td>
</tr>
<tr>
<td>Jour 11</td>
<td>News Writing (4) or Basic Science and Technical Writing (3) or Communicating Technical Information (3)</td>
</tr>
</tbody>
</table>

**required major courses**

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jour 2-3</td>
<td>Brown &amp; White (2)**</td>
</tr>
<tr>
<td>Jour 13</td>
<td>Editing (3)</td>
</tr>
<tr>
<td>Jour 122</td>
<td>Media Ethics and Law (3)</td>
</tr>
<tr>
<td>Jour 124</td>
<td>Politics of Science (3)</td>
</tr>
<tr>
<td>Jour 125</td>
<td>Environment, the Public and the Mass Media (3)</td>
</tr>
<tr>
<td>Jour 128</td>
<td>Writing for Public Relations (3)</td>
</tr>
<tr>
<td>Jour 315</td>
<td>Advanced Reporting (4)</td>
</tr>
<tr>
<td>Jour 323</td>
<td>Scientific and Environmental Controversies (3)</td>
</tr>
<tr>
<td>Jour 361</td>
<td>Internship (3)</td>
</tr>
<tr>
<td>Govt 177</td>
<td>Urban Politics (3)</td>
</tr>
</tbody>
</table>

Thirty-four journalism credits are required.

**Note:** A minimum of three semesters is required on The Brown and White. The course involves work on the student newspaper. One of the three required semesters must be taken during the student’s junior year, and one must be taken during the senior year.

### Science Writing Minor

Students desiring to minor in science writing must be majors in another discipline, preferably a science or engineering. The following courses are required:

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jour 1-2</td>
<td>Brown &amp; White (2) or Internship (2)</td>
</tr>
<tr>
<td>Jour 11</td>
<td>News Writing (4) or</td>
</tr>
<tr>
<td>Jour 123</td>
<td>Basic Science and Technical Writing (3) or</td>
</tr>
<tr>
<td>Jour 124</td>
<td>Politics of Science (3)</td>
</tr>
<tr>
<td>Jour 125</td>
<td>Environment, the Public and the Mass Media (3)</td>
</tr>
<tr>
<td>Jour 323</td>
<td>Scientific and Environmental Controversies (3)</td>
</tr>
<tr>
<td>One other Journalism or Communication course (3)</td>
<td></td>
</tr>
</tbody>
</table>

Seventeen or eighteen credits are required.

### Public Relations Minor

Students minoring in public relations must be majors in another discipline and take the following courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jour 13</td>
<td>Editing (3)</td>
</tr>
<tr>
<td>Jour 127</td>
<td>Public Relations Principles (3)</td>
</tr>
<tr>
<td>Jour 128</td>
<td>Writing for Public Relations (3)</td>
</tr>
<tr>
<td>Jour 229</td>
<td>Public Relations Case Studies (3)</td>
</tr>
<tr>
<td>Jour 233</td>
<td>Public Relations Practicum (1-3)***</td>
</tr>
<tr>
<td>Jour 306</td>
<td>Applied Public Relations (3) or</td>
</tr>
<tr>
<td>Jour 361</td>
<td>Internship (3)</td>
</tr>
</tbody>
</table>

Seventeen credits are required.

***Note:** A minimum of two semesters of one-credit public relations practicum is required.

### Communication Minor

See description under Minor Programs in the College, page 34.

### Computer Writing Laboratories

Students taking journalism courses will receive extensive experience with mass media computer applications. All writing and editing labs are conducted in one of the department's two computer rooms. One is a newspaper production facility with a mixed network of 20 DOS and Macintosh computers, in which the DOS computers are used for text entry and the Macintosh computers are used for pagination of publications. All are connected through a local area network to laser and postscript printers and are used extensively for desktop publishing. The other facility is a local area network with 20 DOS computers, laser printers and an
overhead projection system for classes, labs and demonstrations.

**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 are required to take an internship to acquire professional experience with area newspapers or magazines, or in an institutional, public relations or advertising setting. Science writing minors may take an internship instead of working on The Brown and White.

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. Freshman or sophomore standing; juniors only with consent of department chairperson. (ND)

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 chairperson. (ND)

11. **News Writing (4)** every semester

   Preparation and practice in gathering and writing news; definition and components of news; structure and style of the news story; introduction to interviewing and editing. (ND)

12. **Feature Writing (3)** 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. Trimble. (ND)

13. **Editing (3)** every semester

   Study of and practice in editing and rewriting stories for newspapers and magazines; headline writing; techniques of newspaper and magazine design, including typography, grids, and use of photographs and other artwork; microcomputer-based desktop publishing. Prerequisite: Jour 11 or Jour 123. Trimble. (ND)

101. **Media, Sports and Society (3)** summer

   Analysis of social, political and economic implications of media sports coverage; emphasis placed on media coverage of events of international scope, such as the World Cup, World Series and the Olympics; special attention paid to the role of the sports press in coverage of issues such as AIDS, racism, sexism, drug use and terrorism. Lule.

111. **Sportswriting (3)** summer

   Principles and practice of writing about sports for general print and specialized publications; emphasis placed on instruction in reporting, writing and editing; topics covered include the history of sports journalism; recent trends in the field; ethical considerations, and the exploration of social and political issues through sportswriting. Lule. (ND)

122. **Media Ethics and Law (3)** spring

   First Amendment theory and history; ethical and legal issues involving libel, privacy, obscenity, newsgathering, access, and fair trials; national and international concerns over censorship, prior restraint and manipulation and control of information. Lule. (SS)

123. **Basic Science and Technical Writing (3)** every semester

   Writing about science and technology subjects for audiences ranging from lay persons to scientists and engineers. Includes instruction in news and feature writing plus interviewing for lay audiences, with emphasis on organization and clear writing techniques. As course progresses, material becomes more technical in nature, concentrating on how to write effective technical reports, progress reports, letters and memos. Prerequisite: six hours of science or engineering or consent of department chairperson. S. & K. Friedman. (ND)

124. **STS 124 Politics of Science (3)** spring

   Organization of the U.S. scientific community; interaction with federal government, mass media and society; history of science-government connection; role of science advisory system; technological controversies. S. Friedman. (SS)

125. **Environment, the Public and the Mass Media (3)** fall

   Exploration of environmental problems and public perceptions about them. Roles played in environmental controversies by government, environmental groups, industry and mass media. Risk communication about environmental hazards. S. & K. Friedman. (SS)

127. **Public Relations Principles (3)** fall

   Emphasis on management function of public relations, including research, planning, programming, communications and evaluation. Study of communication and persuasion theory, public opinion, crisis management and ethics. Student teams apply theory to practical organizational problems. Gorney. (SS)

128. **Writing for Public Relations (4)** spring

   Basics of news writing (structure and style) applied to the preparation of informational, promotional and persuasive news releases; 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)

129. Specialized Writing in Public Relations (3) fall Preparation and writing of promotional and publicity materials, including public service announcements, for 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 will be videotaped giving actual media interviews. Prerequisite: Jour 11 or 123 or consent of department chairperson. Gorney. (ND)

135. (Sp sy 135) Human Communication (3) Processes and functions of human communication in relationships and groups. Rosenwein. (SS)

141. Photojournalism (3) summer Ethics and history of photojournalism; instruction and practice in basic camera and darkroom techniques; use of microcomputer to manipulate and print photographs; cropping and sizing photographs and production of layouts using microcomputer-based desk-top publishing. Students must provide own 35mm camera. Trimble, Gorney. (ND)

214. Reporting of Public Affairs (4) spring 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 Govt 177. Trimble. (ND)

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 chairperson. Trimble. (ND)

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)

229. Public Relations Case Studies (3) fall Analysis of public relations programs in business, industry, government, and non-profit organizations. Emphasis on specific problems and methods used. Prerequisite: Jour 127 or consent of department chairperson. Gorney. (ND)

231. Science Writing Practicum (1-3) On-site experience as accredited science reporter at major scientific meetings, or writing and research in university laboratories as part of Science Writing Field Research Program. 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 chairperson. S. Friedman. (ND)

233. Public Relations Practicum (1-3) Practical experience in public relations competitive programs sponsored by professional and academic societies. May be repeated for a maximum of eight credits. Prerequisites: Jour 127, junior standing and consent of department chairperson. Gorney. (ND)

240. Writing for Broadcasting (3) spring Basic writing style for radio and television, and packaging of newscasts. Write, edit and present on-air newscasts and public affairs programs for the campus radio station. Assigned reading for class discussion related to the history, technology and regulation of broadcasting. Gorney. (ND)

246. (IR 246) International Communication (3) 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)

306. Applied Public Relations Study (3) spring Application of crisis planning, management and communication to problems faced by organizations. Teams develop crisis plans and strategies for real clients and engage in mock news conferences to practice effective media interviews. Prerequisites: Jour 127 and Jour 128 or consent of department chairperson. Gorney. (ND)

311. Science and Technical Writing (3) every semester Study of and practice in writing about science and technology for general print and specialized science publications. Includes news and feature articles, report writing and analysis of factors that influence science communication to the public. Emphasis on writing and organizational skills and translation of scientific materials into lay language. Should be taken by upperclass and graduate students instead of Jour 123. Prerequisite: six hours of science or engineering or consent of department chairperson. S. & K. Friedman. (ND)

312. Advanced Science Writing (3) Further practice, on individual basis, in science writing techniques. Prerequisite: Jour 123 or 311. S. Friedman. (ND)

313. Special Topics in Science Communication (1-3) Research or writing involving a topic, medium or issue in science, environmental or technical communication not covered in other courses. Prerequisite: Nine hours in science or environmental writing or consent of the department chairperson. S. Friedman. (SS)
314. Communicating Technical Information (3)
For upperclass students planning on graduate school and graduate students: instructions in writing about technical subjects from an academic perspective. Laboratory reports, journal articles, thesis and dissertations, proposals and oral technical presentations will be highlighted. Prerequisite: Junior standing or permission of department chairperson. K. Friedman. (ND)

315. Advanced Reporting (4) fall
Planning, researching and writing in-depth news projects, with special attention paid to: investigative techniques and research methods; analyzing and interpreting social, political and economic trends; reporting and writing about government and public policy on the local, county, state and federal levels; and covering civil and criminal courts. Emphasis given to organizing and writing longer-form prose. Prerequisites: Jour 11 or 123, and Govt 177; or permission of the department chairperson. Lule. (ND)

320. Journalism Proseminar (3) spring
Intensive research and writing on contemporary issues and problems facing the mass media; methods and approaches for studying the mass media; course culminates with a seminar thesis based on original and comprehensive research. Prerequisite: nine hours in journalism, public relations or communication or consent of the department chairperson. Lule. (SS)

323. Scientific and Environmental Controversies (3) spring
Research and writing on media reporting of controversial scientific and environmental topics. Public opinion polling; computer analysis and media databases. Prerequisite: Jour 11, Jour 123 or Jour 311 or consent of the department chairperson. S. Friedman. (SS)

327. (SPsy 327) Mass Communication and Society (3) spring
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.). Rosenwein. (SS)

361. Internship (1-6) every semester
Professionally supervised work on commercial newspapers, magazines, radio and television stations, or with public relations and advertising organizations. Some internships involve science writing. May be repeated for a maximum of six credits. Prerequisite: Junior or senior standing and declared major or minor in journalism, science writing, public relations or communication and consent of the department chairperson. S. Friedman. (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 130. Public Speaking (3) every semester
Applying the principles of public speaking to making informative and persuasive presentations effectively. Emphasis on speech composition and effective oral communication skills. (HU)

Comm 143. Persuasion and Influence (3) fall
The social, symbolic, and rhetorical means of persuasion and how this persuasive influence is expressed in politics, advertising, and the mass media. 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 evaluation interview. Instructor will use role-playing and videotaping. Students will prepare and conduct simulated interviews. Wills. (ND)

Comm 325. Special Topics in Communication (1-3)
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 chairperson. (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. (ND)

Languages

Courses are listed alphabetically under Modern Foreign Languages.
Latin American Studies

See listings under Modern Foreign Languages. See also International Careers, where an undergraduate may focus on Latin America as a geographical concentration.

Law

Professor. Perry A. Zirkel, J.D., LL.M. (Yale), Ph.D. (Connecticut), University Professor of Education and Law.
Associate professors. George A. Nation III, J.D. (Villanova).
Assistant professor. Matthew A. Melone, J.D. (Pennsylvania), C.P.A.

The Department of Business offers the following undergraduate and graduate courses:

Undergraduate Courses

11. 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.

Courses numbered 200 and above in the College of Business and Economics are open to sophomore's only on petition.

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 11, Eco 12, and junior standing.

202. Business Law (3) every semester
The law of sales, contracts, agency, business organizations, secured transaction, property and negotiable instruments. Prerequisite: Law 201.

221. (Phil 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. Lindgren (HU)

371. Directed Readings (1-3)
Readings in various fields of law, designed for students who have a special interest in a field of law.

372. Special Topics (3)
Special problems and issues in commercial law.

Graduate Courses

404. 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.

406. The Legal Aspects of International Business
A study of the international legal environment of business. The problem method is used to analyze the differences, difficulties, and opportunities of international business. Topics to be studied include: importing and exporting goods, nontariff trade barriers, transfers of technology, foreign direct investment, and doing business in the EEC.

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. Not available to students with two or more courses in taxation. Prerequisite: a basic course in accounting.

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 of Graduate Programs and Professional Education; Benjamin Litt, Ph.D. (N.Y.U.); James W. Schmottter, Ph.D. (Northwestern), dean of the College of Business and Economics; John E. Stevens, Ph.D. (Cincinnati).
Associate professors. Peter P. Poole, Ph.D. (Penn State); Peter M. Saunders, Ph.D. (University of Toronto); Theodore W. Schlie, Ph.D. (Northwestern); Susan A. Sherer, Ph.D. (Pennsylvania).
Instructor. Douglas D. Moesel, M.S. (Oklahoma State).
Adjunct faculty. Don S. Follett, M.S. (Cornell); Laurie Gustley-Hackett, M.S. (Lehigh); Mehdi Hojjat, Ph.D. (Lehigh); Dennis D. Newhart, MBA (Lehigh); James R. Seifert, M.S.E.E. (Lehigh); Kenneth Stott, Jr., Ph.D. (Lehigh); Colleen Zvosec, M.B.A. (Chicago).

Management Program and Courses

The Department of Business offers an undergraduate management major. Major will select either the Specialization (15 hours) or Interfunctional (18 hours) track shown below:

Specialization (15 hours)
required courses:
Mgt 302 Quantitative Models-Conceptual (3)
Mgt 321 Organizational Behavior Workshop (3)
*Plus at least one of the following:
Mgt 309 Industrial Purchasing and Materials Management (3)
Mgt 311 LUMAC Management Assistance Counseling (3)
Mgt 331 Industrial Relations and Public Policy (3)
Mgt 333 Personnel Management (3)

Up to two of the following:
Acct 324 Cost Accounting (3)
Eco 333 Managerial Economics (3)
Eco 334 Labor-Management Relations
Eco 335 Labor 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 Marketing in the Industrial Environment (3)
IE 309 Introduction to Information Systems (3)
IE 334 Organizational Planning and Control (3)
IE 332 Product Quality (3)

*Courses other than Mgt 302 and Mgt 321 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) or
Mkt 321 Marketing in the Industrial Environment (3)

Plus one of the following:
IE 309 Introduction to Information Systems (3)
IE 334 Organizational Planning and Control (3)
IE 332 Product Quality (3)

**Undergraduate Courses**

Mgt 1. *Introduction to Business Computing* (3) fall and spring
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 data base management systems. Students will develop a working knowledge of microcomputers, mainframes and the campus-wide network. Limited to freshmen only. (Mgt 1 will be a prerequisite for many courses in the College of Business and Economics.)

Mgt 101. (ECO 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.

Courses numbered 200 and above in the College of Business and Economics are open to sophomores only on petition.

Mgt 269. *Management of Operations in Organizations* (3) fall-spring
Design, operation and control of activities necessary to generate goods or services of profit and nonprofit organizations. Basic concepts and quantitative modes used in operations. Eco 145, Math 44. Trent

Mgt 270. *Organization Theory and Behavior* (3) fall-spring
Formal organizations as ongoing systems. Emphasis is placed on the introduction of theory applicable to the management of human behavior in work environments. Issues at the individual, group, and organizational levels of analysis are addressed. Topics covered include motivation, stress, career processes, leadership, conflict management, decision making, work politics, organizational design, and organizational development. Poole

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. Moessel, Barseness

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 105, Acct 111 and Mgt 269.

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 chairperson. Students may not receive credit for both Mgt 306 and Mgt 301. 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. Prerequisite: Mgt 269 or equivalent. Kolchin

Mgt 311. LUMAC Management Assistance Counseling (3) fall-spring
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 270 and permission of the department chairperson. Poole, Kolchin, Litt

Mgt 331. Industrial Relations and Public Policy (3)
An examination of the evolution and current status of U.S. public policy toward the organization and recognition of labor unions, collective bargaining, labor contract administration, and arbitration of disputes as expressed in federal statutes, court decisions, and National Labor Relations Board rulings. Stevens

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 270. 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 chairperson. May be repeated.

Mgt 372. Special Topics (1-3)
Special problems and issues in management for which no regularly scheduled coursework exists. When offered as group study, coverage varies according to interests of instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

For Graduate Students

Mgt 401. Quantitative Methods in Business and Economics (3)
Management science methods and applications. Mathematical programming, simulation, decision theory, game theory, network models and statistics. Prerequisite: Eco 401 or equivalent.

Mgt 409. Purchasing and Materials Management (3)
Overview of the purchasing and materials functions in organizations: Negotiation, buying, receiving, storing, inventory control, value analysis, legal aspects, and specialized problems in institutional and government procurement. Combination of lectures and case analyses. Kolchin

Mgt 413. Organizational Behavior and Management (3)
Interpersonal and group behavior in organizations. Issues of organization work and perception, motivation, communications, conflict, leadership, and organization structure. Kolchin, Litt, Poole

Mgt 423. Operations Management (3)
Capacity planning and aggregate scheduling, inventory theory including MRP and JIT, production scheduling, standards and quality control, and project management. Prerequisite: Mgt 401 (or equivalent). Sherer, Trent

Mgt 425. Human Resource Management (3)
A survey of personnel management activities in organizations. Topics include human resource planning, recruitment, selection, equal employment opportunity, evaluation, compensation, career planning, safety and health. Kolchin

Mgt 429. Managerial Policy and Decision-Making (3) fall-spring
Integration of theory and analytic techniques through intensive investigation of complex organizational, strategic and financial problems in industrial and nonbusiness entities. Case studies. Prerequisite: graduate-level exposure to accounting, economics, finance, management and marketing. An MBA candidate should take the course near the end of the MBA program. Stevens

Mgt 430. (IE 430) Management Science Project (3)
As an individual or as a member of a small group, analysis of a management problem and the design of its solution is made incorporating management science techniques. An individual written report is required. Recommended that it be taken in the last semester of the M.S. in management science program.
Mgt 431. Organizational Design and Change (3) fall
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: Mgt 413. Bonge

Mgt 433. Corporate Enterprise: Concepts and Issues (3)
Examines issues relevant to modern corporate enterprises: managing technological innovation; role of public policy; managerial values-ethics and human resources. Barsness, Litt

Mgt 435. Organizational Decision Processes (3)
Examines individual responsibility and information handling styles in managerial decision-making processes in formal organizations. Negotiated decision-making, joint problem solving, and values based decision-making processes. Prerequisite: Mgt 413. Litt

Mgt 445. (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.

Mgt 447. 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.

Mgt 453. (MoT 453) 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 techniques, and trustworthiness of findings. A field research project is required.

Mgt 455. 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.

Mgt 457. Technology Management Seminar (3)
Review of current literature on technology management with emphasis on relation 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. Bean, Schlie

Mgt 467. (MoT 467) Strategic Information Systems (3)
Study of the impact of information technology on business strategy and the influence of information resources on competition. Explores development and management of competitive information systems strategy, including risks associated with investments in information systems technology. Case studies and applications include operations management, financial and accounting services, and marketing. Sherer

Mgt 471. Directed Readings (1-3)
Graduate readings in management not covered in regularly scheduled coursework. Prerequisite: consent of the department chairperson. May be repeated.

Mgt 472. Special Topics (1-3)
Special problems and issues in management for which no regularly scheduled graduate coursework exists. When offered as group study, coverage will vary according to the interests of instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

Management of Technology

Program director. Alden S. Bean, Ph.D. (Northwestern); Wm. R. Kenan, Jr. professor of management and technology.

Program faculty. 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), assistant professor of accounting; Theodore W. Schlie, Ph.D. (Northwestern), associate professor of management; Susan A. Sherer, Ph.D. (Pennsylvania), assistant professor of management; E. Sarah Slaughter, Ph.D. (M.I.T.), assistant professor of civil engineering; 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), assistant professor of industrial engineering; Todd Watkins, Ph.D. (Harvard), assistant professor of economics; Samuel C. Weaver, Ph.D. (Lehigh), adjunct professor of finance.

The program requires 36 credit hours of graduate work, including a thesis. It is designed for students with undergraduate degrees in science or engineering and at least four 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 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 Coursework

Acct 413. Managerial Accounting and Decision-Making (3)
(A two-day financial accounting seminar offered during orientation will be accepted as the prerequisite for MOT students.)

Eco 467. Technology and Economic Analysis (3)
Theoretical and empirical bases for understanding the productivity effects of technological change in economic systems; relationships between technological change and industry structure; and applications of economic analysis to the effects of technological change in the firm. (This course is intended only for MOT students.)

Fin 411. Financial Management (3)
(Acct 413 and Eco 472 will be prerequisites for MOT students.)

Hist 407. History of American Industrial Technology (3)

Mot 421. Technology, Manufacturing, and Competitive Strategy (3)
Industry analysis and competitiveness; competitive strategy formulation and implementation; value chain analysis; manufacturing and technology strategy; manufacturing's contribution to competitive advantages in quality, cost, variety, and new product availability; segmentation, substitution, and vertical integration.

Mot 432. 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.

Mot 440. 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.

Mot 450. 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.

Mkt 441. New Product Planning in Marketing and Research and Development (3)

Mot 477. 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.

IE 442. Total Quality Management (3)
Other elective courses may be taken with permission of MoT Advisor.

Elective Courses

Mkt 467. Strategic Information Systems (3)

Mkt 490. Thesis (3)
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 Fridays 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

421. Managing the Manufacturing Life Cycle (3)
Manufacturing as an integrated technical-social-economic system. Linkages between corporate and manufacturing strategies. Combines a systems perspective with project leadership and membership skills for introducing and managing change into manufacturing systems at various life cycle stages.

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.

425. Production Planning and Resource Allocation (3)
Capacity planning, scheduling, inventory control, and other topics in the management of manufacturing resources. Discrete and continuous simulation models for analysis and design of production systems. Factory information systems and data bases for computer integrated manufacturing.

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.

431. Technological Innovation in the Manufacturing Organization (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.

433. Technology and the Factory of the Future (3)
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.

451. Manufacturing Systems Engineering Project (1-3)
490. Manufacturing Systems Engineering Thesis (1-6)
496. Microelectronics Manufacturing Systems & Technologies (3)
Manufacturing engineering in electronics manufacture: crystal growth, doping, thin film deposition 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 professors. Melinda Smith de Borrero, Ph.D.
(South Carolina); Carolyn J. Simmons, Ph.D. (Florida).
Adjunct faculty. Therese A. Maskulka, D.B.A. (Kent State).

Career Opportunities in Marketing

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.

For undergraduates, the marketing major offered by the Department of Business consists of fifteen credit hours from the following courses:

**Required courses**
- Mkt 312 Marketing Research (3)
- Mkt 313 Marketing Communications (3)

**Elective courses**
- Three courses (nine credit hours) from the following:
  - Mkt 315 Consumer Behavior (3)
  - Mkt 316 Advertising (3)
  - Mkt 319 New Product Planning (3)
  - Mkt 320 International Marketing (3)
  - Mkt 321 Business to Business Marketing (3)
  - Mkt 330 Retail Management (3)
  - Mkt 371 Directed Readings (1-3)

**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 211. 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 or Eco 11 and 12. Falcinelli

**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 211. de Borrero and Simmons

**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 211. de Borrero and 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. Prerequisite: Mkt 211 and Mkt 312. Simmons

**Mkt 316. Advertising (3) spring**
Analysis of advertising campaigns and the societal implications of advertising are considered from a managerial perspective. Prerequisite: Mkt 313. 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 211 and Fin 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 225 and Mkt 211. Hansz, J. Maskulka

**Mkt 321. Business to Business Marketing (3)**
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.

**Mkt 330. Retail Management (3) fall**
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 211 and Mkt 312. T. Maskulka

**Mkt 371. Directed Readings (1-3)**
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 chairperson. May be repeated.

**Mkt 372. Special Topics (1-3)**
Special problems and issues in marketing for which no regularly scheduled coursework 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 chairperson. May be repeated.
For Graduate Students

Graduate students are encouraged to meet with the department chair to discuss their career interests and program planning before beginning formal graduate coursework.

Mkt 411. Marketing and the Global Firm fall
Emphasis is placed on understanding the process of globalization and its resultant impact on the firm's marketing function. Case analysis and/or computer simulations are employed to enhance the student's understanding of the challenges and opportunities facing the firm pursuing globalization. Prerequisite: Mkt 413. Hansz, J. Maskulka

Mkt 413. Marketing Management (3) fall-spring
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: Eco 408 (or concurrently). Hansz, J. Maskulka, Simmons

Mkt 433. Strategic Marketing (3)
Strategic issues facing corporations in a highly competitive and rapidly changing environment. Case studies and preparation of a strategic plan. Prerequisite: Mkt 413.

Mkt 435. 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: Mkt 413. Hansz, Simmons

Mkt 437. Advertising Management (3) spring
Analysis of consumer and industrial advertising campaigns from a managerial perspective. Prerequisite: Mkt 413. J. Maskulka

Mkt 439. Industrial Marketing and Sales Management (3) fall
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 bidding proposals. Prerequisites: Fin 411 and Mkt 413. Smackey

Mkt 441. New Product Planning in Marketing and Research and Development (3) spring
The design, development and marketing of new products and processes in high technology industries; inventors and the importance of patents and licensing; generation and screening of ideas; commercialization term project. Prerequisites: Fin 411 and Mkt 413. Smackey

Mkt 443. Buyer Behavior and Marketing Management (3)

Concepts, methodologies, and current research involving consumer and organizational buying behavior. Prerequisite: Mkt 413. de Borrero and Simmons

Mkt 445. 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 of sales personnel; and integrating sales with other marketing activities. Prerequisite: Mkt 413.

Mkt 452. Causal Modeling (3)
This course brings together in a single analytical framework 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. Prerequisites: Intermediate statistical theory or consent of department chairperson.

Mkt 462. Research Methodology (3) spring, odd-numbered years
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. Open only to doctoral students. de Borrero and Simmons

Mkt 463. Advanced Data Analysis (3) spring, even-numbered years
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 permission of department chairperson.

Mkt 471. Directed Readings (1-3)
Graduate reading in marketing not covered in regularly scheduled courses. When offered as group study, coverage varies according to the interests of the instructor and students. Prerequisite: consent of the chairperson. May be repeated.
Mkt 472. Special Topics (1-3)
Problems and issues in marketing for which no regularly scheduled graduate coursework exists. When offered as group study or internship, coverage varies according to the interests of the instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

Materials Science and Engineering

Professors. David B. Williams, Ph.D. (Cambridge), Harold Chambers Senior Professor, chairperson; S. Kenneth Tarby, Ph.D. (Carnegie-Mellon), R.D. Stout Professor, associate chairperson; Helen M. Chan, Ph.D. (Imperial College of Science and Technology, England) Class of '61 Professor; Martin P. Harper, Ph.D. (Leeds, England), Alcoa Professor, director of Materials Research Center; Richard H. Ziemkiewicz, Ph.D. (Lehigh), New Jersey Zinc Professor; Himanshu Jain, Engr. Sci. D. (Columbia); Charles E. Cyman, Ph.D. (M.I.T.); Arnold R. Marder, Ph.D. (Lehigh); Michael R. Notis, Ph.D. (Lehigh); Alan W. Pense, Ph.D. (Lehigh), Provost; David A. Smith, Ph.D. (Cambridge).

Assistant professors. Katy Barmak, Ph.D. (M.I.T.); Raymond A. Pearson, Ph.D. (Michigan); Jeffrey M. Rickman, Ph.D. (Carnegie-Mellon).

Adjunct professors. Yung-Haw Hu, Ph.D. (Lehigh); 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.); Walter C. Hahn, Ph.D. (Penn State); Ralph J. Jaccodine, Ph.D. (Notre Dame); 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. Bentsen; John Bury, Ph.D. (Cambridge); John DuPont, B.S. (Ohio State).

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 study or internship, coverage varies according to the interests of the instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

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.

Major Requirements
The recommended sequence of courses is shown below. The standard freshman engineering year is shown on page 33.

sophomore year, first semester (16 credits)*
Math 23 Analytic Geometry & Calculus III (4)
Phy 21, 22 Introductory Physics II and Laboratory (5)

Eco 11 Principles of Microeconomics (3) or
Eco 12 Principles of Macroeconomics (3)
Mat 33 Engineering Materials and Processes (3) or

HSS Humanities/Social Sciences Elect (3)
Mat 10 Materials Laboratory (1)

*Mat 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 (15 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 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

for people trained in science and technology of materials.
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Mat 218</td>
<td>Transformations</td>
<td>3</td>
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<tr>
<td>HSS</td>
<td>Mechanical Behavior of Materials</td>
<td>3</td>
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<td></td>
<td>Humanities/Social Sciences Elective</td>
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**junior year, second semester** (18 credits)

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Mat 101</td>
<td>Professional Development</td>
<td>2</td>
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<tr>
<td>Mat 204</td>
<td>Processing and Properties of Polymeric Materials</td>
<td>3</td>
</tr>
<tr>
<td>Mat 206</td>
<td>Processing and Properties of Metals</td>
<td>3</td>
</tr>
<tr>
<td>Mat 214</td>
<td>Processing and Properties of Ceramic Materials</td>
<td>3</td>
</tr>
<tr>
<td>ECE 81</td>
<td>Principles of Electrical Engineering</td>
<td>4</td>
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<tr>
<td>Elect.</td>
<td>Elective</td>
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**senior year, first semester** (18 credits)

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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>Mat 201</td>
<td>Physical Properties of Materials</td>
<td>3</td>
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<tr>
<td>Mat 301</td>
<td>Design and Selection of Engineering Materials</td>
<td>3</td>
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<tr>
<td>Mat 303</td>
<td>Macroprocessing of Materials</td>
<td>3</td>
</tr>
<tr>
<td>HSS</td>
<td>Humanities/Social Sciences Elective</td>
<td>3</td>
</tr>
<tr>
<td>IE 111</td>
<td>Engineering Probability and Statistics (3) or</td>
<td>3</td>
</tr>
<tr>
<td>Math 231</td>
<td>Probability and Statistics</td>
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**senior year, second semester** (18 credits)

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Mat 302</td>
<td>Electronic Properties of Materials</td>
<td>3</td>
</tr>
<tr>
<td>Mat 338</td>
<td>Materials Reports</td>
<td>3</td>
</tr>
<tr>
<td>ChE 60</td>
<td>Unit Operations Survey</td>
<td>3</td>
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<tr>
<td>Elect.</td>
<td>Elective</td>
<td>3</td>
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<tr>
<td>Approved. Elect.</td>
<td>Approved Elective (3)**</td>
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**Undergraduate Courses**

**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.

**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)

**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)

**107. Special Topics in Materials (1-3)**

A study of selected topics in materials science and engineering not covered in other formal courses.

**192. Structural Materials (3) fall**

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*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.**
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. (ES3)

**For Advanced Undergraduates and Graduate Students**

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. Prerequisite: Phys 21, Mat 33, Math 205. Janin. (ES2.5), (ED0.5)

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. Prerequisite: Chem 21; Mat 10 and Mat 33 previously or concurrently. Chan, Lyman, Notis, Williams. (ES 3)

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)

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, Notis. (ES 3)

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)

214. **Processing and Properties of Ceramic Materials** (3) spring

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. Prerequisite: Mat 203, Mat 205. Williams, Notis. (ES 2), (ED 1)

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)

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. Notis

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 results. Selection of research topic and preparation defense of research proposal. Restricted to a small number of students selected by the department from those who apply. (ES 3)

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.

301. **Design and Selection of Engineering Materials** (3) fall
Review of ceramics, metals, plastics and composites as engineering materials. Analysis of design requirements for material components. Selection of materials with appropriate
Description of Courses

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302. Electronic Properties of Materials (3) spring
The electronic structure of materials, i.e., bond 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. Prerequisite: Mat 33, Mat 201, Mat 203. Jain, Notis. (ES 2), (ED 1)

303. Macroprocessing of Materials (3) fall
Basic concepts of stress, strain and stress-strain behavior during plastic flow. Yield criteria and approximations to the experimental stress-strain curve. Work and power of deformation. Description and analysis of numerous forming processes. Additional concepts as: friction, hydrodynamic lubrication, forming of metallic and nonmetallic composite materials, and pressure induced ductility. Hertzberg. (ES 2), (ED 1)

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 33 or equivalent, Mech 2. (ES 2), (ED 1)

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.

312. (ChE 312, Chem 312) Fundamentals of Corrosion (3)

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 303. (ES 1), (ED 2)

315. Physical Properties of Structural and Electronic Ceramics (3)
Structure-property relationships in ceramics. Mechanical behavior including plasticity, hardness, elasticity, strength and toughening mechanisms. Thermal behavior including specific heat, thermal expansion, thermal conduction and thermal shock. Electrical behavior including application of tensors and crystal physics to electroceramics. Prerequisites: Mat 214 or consent of instructor. Harmer. (ES 3)

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)

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 chairperson. Prerequisite: Consent of department chairperson. (ES 3)

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)

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)

329. Industrial Project (4) fall
To be taken concurrently with Mat 327. Course material is the same as Mat 327. (ED 4)

333. (EES 337, Chm 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)

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 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 chairperson. Williams, Lyman. (ES 4)

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 chemistry of the fabrication steps, mathematical modelling of the transport and chemical reaction phenomena, and interpretation of experimental methods and data. Prerequisite: a course in thermodynamics and senior standing. (ES 3)

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. (ES 3)

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)

343. (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)

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)

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)

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)

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)

396. (Chm 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 interaction. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, and photoconductivity. Prerequisite: Chm 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. 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 Graduate School 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 thirty 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 Graduate School, the student passes a qualifying 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 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. Non-crystalline 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.

406. Solidification (3)
Structure, theory and properties of liquids. Homogeneous and heterogeneous nucleation theory and experimental results. 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.

408. Transformations (3) fall
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 non-metallics. Prerequisite: Mat 205 and 216 or equivalent. Marder

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 chairperson.

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 experimentation and computation. Prerequisite: Mat 205 or equivalent. Pense

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

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

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.

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 chairperson. Notis, Hamner

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.

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

418. Fatigue and Fracture of Engineering Materials (3) fall

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 301 or equivalent. Marder

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 311 or Mech 313 or equivalent. Hertzberg and Traub

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

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 chairperson.

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.

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

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 214 or equivalent. Harmer

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. Jain

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.

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 chairperson. Wei

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. Prerequisite: one course in linear algebra and one course in quantum mechanics. Klier

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 chairperson.

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.

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 chairperson.

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 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.

485. (Chm 485, ChE 485) Polymer Blends and Composites (3) fall
An intensive study of the 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), chairperson; 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); Jacob Y. Kazakia, Ph.D. (Lehigh); Samir A. Khabbaz, Ph.D. (Kansas); Jerry P. King, Ph.D. (Kentucky); Gregory T. McAllister, Ph.D. (Berkeley), head of the Division of Applied Mathematics and Statistics; George E. McCluskey, Ph.D. (Pennsylvania), 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); 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, Yugoslavia); David L. Johnson, Ph.D. (M.I.T.); Clifford S. Queen, Ph.D. (Ohio State); Penny D. Smith, Ph.D. (Polytechnic Institute of Brooklyn); Susan Szczepanski, Ph.D. (Rutgers); Ramamirtham Venkataraman, Ph.D. (Brown).
Assistant professors. Garth Isaak, Ph.D. (Rutgers); Terrence Napier, Ph.D. (University of Chicago).


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 three calculus sequences: Math 21, 22, 23; Math 31, 32, 33; Math 41, 44. 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 41-44. Math 41, 43, and 44 are designed primarily for students in business and the biological sciences. Math 44 should normally be taken in the semester following Math 41, while Math 43 may be taken at any time. Credit will be awarded for only one course in each of the following three groups: 21, 31, and 41; 22, 32, and 44; 23 and 33. If two courses in the same group are taken, credit will be given for the one with the larger number of hours.

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
- Math 205 Linear Methods (3) or
- Math 320 Ordinary Differential Equations (3)
- Math 219, 220 Principles of Analysis I and II (6)
- Math 243 Algebra (3)
- Math 244 Linear Algebra (3)
- Math 316 Complex Analysis (3) or
- Math 208 Complex Variables (3)
- Math Electives (12)

Note: The twelve hours of electives must be approved by the student’s major advisor. A student must achieve an average of 2.0 or higher in major courses.

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.

Each student is assigned a faculty advisor to guide an individual program and supervise the choice of electives.

General Mathematics Option
College and University Requirements (37 credit hours) See page 33.

Required Major Courses (39 credit hours)
- Math 21, 22, 23 Calculus (12) or
- Math 31, 32, 33 Honors Calculus (12)
- CSc 11 Introduction to Structured Programming (3) and
- CSc 15 Data Structures (3) or
- Eng 1 Engineering Computations (3) and
- CSc 17 Structured Programming and Data Structures (4)
- Math 12 Statistical Methods or
- Math 231 Probability and Statistics (3)
- Math 205 Linear Methods (3)
- Math 208 Complex Variables or
- Math 316 Complex Analysis (3)
- Math 219 Principles of Analysis I (3)
- Math 220 Principles of Analysis II (3)
- Math 243 Algebra (3)
- Math 244 Linear Algebra (3)

Major Electives (12 credit hours) Four 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 page 33.

**Required Major Courses** (45 credit hours)
- Math 21, 22, 23 Calculus (12) or
- Math 31, 32, 33 Honors Calculus (12)
- CSc 11 Introduction to Structured Programming (3) and
- CSc 15 Data Structures (3) or
- Eng 1 Engineering Computations (3)
- Math 12 Statistical Methods or
- Math 231 Probability and Statistics (3)
- Math 205 Linear Methods (3)
- Math 208 Complex Variables or
- Math 316 Complex Analysis (3)
- Math 219 Principles of Analysis I (3)
- Math 230 Numerical Methods (3)
- Math 243 Algebra (3) or
- Math 261 Discrete Structures (3)
- Math 244 Linear Algebra (3)
- Math 320 Ordinary Differential Equations (3)
- Math 322 Methods of Applied Analysis I (3)

**Major Electives** (12 credit hours)
Four courses with specific mathematical content chosen with the approval of the faculty advisor.

**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 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) See page 33.

**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 12 Basic Statistics (4)
- Math 205 Linear Methods (3)
- Math 309 Theory of Probability (3)

**Math 310** Probability and Its Applications (3)
**Math 312** Applied Statistics (3)
**Math 334** Mathematical Statistics (3)
**Math 338** Regression Analysis (3)
**Math 374** Statistical Project (3)

**CSc 1** Introduction to Structured Programming (3)
**CSc 15** Data Structures (3)

*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)
Four courses chosen from: Math 208, 219, 230, 244, 320, 322, IE 221, 222, 316, 332, 339.

**Professional Electives** (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.

The major and professional electives must be approved by the faculty advisor.

**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 twelve credit hours of work shown below, and Math 23 or 33. For substitutions, the student should consult the chairperson.

**Minor in Pure Mathematics**
- Math 219, 243, 244
- Math 220 or 303 or 307 or 316 or 342

**Minor in Applied Mathematics**
- Two of Math 205, 208, 230, 231, 244, 320
- Math 322
- Math 323 or 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**
- Phys 21, Astr 2
Undergraduate Courses

0. Precalculus (0)
Review of the elementary mathematics needed to study calculus. No academic credit. Usually offered in the summer. (MA)

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)

9. Introduction to Finite Mathematics (3) fall
Systems of linear equations, matrices, introduction to linear programming. Sets, counting methods, probability, random variables, introduction to Markov chains. (MA)

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)

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)

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)

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)

31. Honors Calculus I (4) fall
Same topics as in Math 21, but taught from a more thorough and rigorous point of view. Prerequisite: Math 31. (MA)

33. Honors Calculus III (4) fall
Same topics as in Math 23, but taught from a more thorough and rigorous point of view. Prerequisite: Math 32. (MA)

41. Survey of Calculus I (3) fall-spring
Functions including the exponential, logarithmic, and trigonometric functions; limits; continuity; differentiation with applications to maximum and minimum problems; antidifferentiation. (MA)

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)

44. Survey of Calculus II (3) fall-spring
Indefinite and definite integrals and the fundamental theorem of calculus with applications; numerical integration; elementary differential equations; functions of several variables and partial derivatives with applications to extremal problems. Prerequisite: Math 41 or Math 21 or consent of the department chairperson. (MA)

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)

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)

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 chairperson. (MA)
For Advanced Undergraduates and Graduate Students
For students who have not taken their elementary mathematics at Lehigh, the prerequisites for certain advanced courses are stated in terms of the number of credit hours of calculus.

202. Problem Solving (1)
Practice in solving problems using calculus, linear algebra, probability, and statistics. Problems taken from actuarial examinations and mathematics contests. Prerequisites: Math 205 and Math 231 or consent of the department.

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 Math 33. (MA)

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)

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)

219. Principles of Analysis I (3) 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)

220. Principles of Analysis II (3) spring
Continuation of Math 219. Functions of several variables; line and surface integrals; implicit functions. Prerequisite: Math 219. (MA)

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)

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 44. (MA)

234. Fractal geometry (3)
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 32. (MA)

243. Algebra (3) spring
Introduction to basic concepts of modern algebra: groups, rings, and fields. (MA)

244. Linear Algebra (3) fall
Thorough treatment of the solution of n 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 43 or Math 205 or Math 243. (MA)

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)

303. Mathematical Logic (3) 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. (MA)

304. Axiomatic Set Theory (3) spring
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 chairman. (MA)

307. General Topology I (3) 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)

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 44. (MA)

310. Probability and Its Applications (3) 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 chairperson. (MA)

312. **Applied Statistics (3)**
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)

316. **Complex Analysis (3)**
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)

320. **Ordinary Differential Equations (3)**
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 and Math 244. (MA)

322. **Methods of Applied Analysis I (3)**
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 chairperson. (MA)

323. **Methods of Applied Analysis II (3)**
Green's functions; integral equations; variational methods; asymptotic expansions, method of saddle points; calculus of vector fields, exterior differential calculus. Prerequisite: Math 322. (MA)

327. **Groups and Rings (3)**
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 243 or consent of the department chairperson. (MA)

329. **Recursive Functions and the Theory of Computation (3)**
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)

334. **Mathematical Statistics (3)**
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)

338. **Regression Analysis (3)**
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)

340. **(CSc 340) Design and Analysis of Algorithms (3)**
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 23 and CSc 15, or consent of the department chairperson. (MA)

341. **Mathematical Models and Their Formulation (3)**
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 205. (MA)

342. **Number Theory (3)**
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 conjecture, partitions. Prerequisite: Math 219 or consent of the department chairperson. (MA)

347. **Problem Solving (1)**
Emphasis on problems in analysis, linear algebra, and applications. May be repeated for credit with consent of the department chairperson. Prerequisites: Math 219 and Math 244. (MA)

350. **Special Topics (3)**
A course covering special topics not sufficiently covered in listed courses. Prerequisite: consent of the department chairman. May be repeated for credit. (MA)

371. **Readings (1-3)**
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 chairperson. May be repeated for credit. (MA)
374. Statistical Project (3)
Supervised field project or independent reading in statistics or probability. Prerequisite: consent of the department chairperson. (MA)

Graduate Programs in Mathematics
The department offers graduate programs leading to the degrees of master of science in mathematics and the doctor of philosophy in 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
The master's program demands thirty credit hours of graduate courses with at least eighteen 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.

With a judicious choice of courses a student in the master's program can specialize in pure mathematics, applied mathematics, or statistics. The M.S. degree can serve both as a final degree in mathematics or as an appropriate background for the Ph.D. degree.

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 some 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.

Graduate Programs in Applied Mathematics
See program description on page xx.

Graduate Courses
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 department chairperson.

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 and theorems; Lebesgue-Stieltjes integral. Prerequisites: Math 307 and Math 401.

404. Mathematical Logic (3)
Topics in quantification theory relevant to formalized theories, recursive functions, Godel's incompleteness theorem; algorithms and computability.

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.

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.

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.

408. Algebraic Topology I (3)
Polyhedra; fundamental groups; simplicial and singular homology.

409. Mathematics Seminar (1-6) fall
An intensive study of some field of mathematics not offered in another course. Prerequisite: consent of the department chairperson.

410. 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 chairperson.

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 chairperson.
416. **Complex Function Theory (3)** fall
Continuation of Math 316. Prerequisite: Math 316 or consent of the department chairperson.

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.

421. **Introduction to Wavelets (3)**
Continuous and discrete signals; review of Fourier analysis; discrete wavelet; 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.

423. **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, Stoke’s theorem, the Hodge theorem. Prerequisite: Math 219, 220, or Math 243 or Math 244 or Math 205 with consent of instructor.

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.

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.

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 chairperson.

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.

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.

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.

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.

444. **Algebraic Topology II (3)**
Continuation of Math 408. Cohomology theory, products, duality. Prerequisite: Math 408.

445. **Topics in Algebraic Topology (3)**
Selected topics reflecting the interests of the professor and the students. Prerequisite: Math 444.

449. **Topics in Algebra (3)**
Intensive study of topics in algebra with emphasis on recent developments. Prerequisite: consent of the department chairman. May be repeated for credit with the consent of the department chairperson.

450. **Special Topics (3)** fall-spring
Intensive study of some field of the mathematical sciences not covered in listed courses. Prerequisite: consent of the department chairman. May be repeated for credit with the consent of the department chairperson.

453. **Function Theory (3)**
The development of one or more topics in function theory, such as analytic continuation, maximum modulus principle, conformal representation, Taylor series analysis, integral functions, Dirichlet series, functions of several complex variables. Prerequisite: Math 416.

455. **Topics in Number Theory (3)**
Selected topics in algebraic and analytic number theory. Prerequisites: Math 316 and Math 327. May be repeated for credit with consent of the department chairperson.

461. **Topics in Mathematical Statistics (3)**
An intensive study of one or more topics such as theory of statistical tests, statistical estimation, regression, analysis of variance, nonparametric methods, stochastic approximation, and decision theory. Prerequisites: Math 334 and Math 401. May be repeated for credit with consent of the department chairperson.

462. **Nonparametric Statistics (3)** fall
Order and rank statistics; tests based on runs, signs, ranks, and order statistics; chi-square and Kolmogorov-Smirnov tests for
goodness of fit; the two-sample problem; confidence and tolerance intervals. Prerequisite: Math 231 or 309.

463. Advanced Probability (3)
Measure theoretic foundations; random variables, integration in a measure space, expectations; convergence of random variables and probability measures; conditional expectations; characteristic functions; sums of random variables, limit theorems. Prerequisites: Math 309 and Math 401.

464. Advanced Stochastic Processes (3)
Theory of stochastic processes; stopping times; martingales; Markov processes; Brownian motion; Skorohod imbedding; Brownian bridge, laws of suprema; Gaussian processes. Prerequisites: Math 309 and Math 401.

471. Homological Algebra (3)
Modules, tensor products, categories and functions, homology functors, projective and injective modules. Prerequisite: Math 428.

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.

490. Thesis

499. Dissertation

Mechanical Engineering and Mechanics

Professors. Robert P. Wei, Ph.D. (Princeton), Paul B. Reinhold Professor; chairman; Charles R. Smith, Ph.D. (Stanford), associate 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), G. Whitney Snyder Professor; D. Gary Harlow, Ph.D. (Cornell); Ronald J. Hartranft, Ph.D. (Lehigh); Stanley H. Johnson, Ph.D. (Lehigh), G. Whitney Snyder Professor; D. Gary Harlow, Ph.D. (Cornell); Ronald J. Hartranft, Ph.D. (Lehigh); Stanley H. Johnson, Ph.D. (Lehigh); John Ochs, Ph.D. (Penn State); 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 Voloshin, Ph.D. (Tel-Aviv, Israel); J. David A. Walker, Ph.D. (Western Ontario, Canada).

Associate professors. Meng-Sang Chew, Ph.D. (Columbia); John P. Coulter, Ph.D. (Delaware); Antonios Liakopoulos, Ph.D. (Florida); Robert A. Lucas, Ph.D. (Lehigh); Tulga M. Ozsoy, Ph.D. (Istanbul, Turkey); N. Duke Perreira, Ph.D. (California, Los Angeles).

Assistant professor. Alparslan Öztekin, Ph.D. (Illinois)

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 in either degree are equipped for work in engineering, research and development and in 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 curricula, candidates for either degree may combine the study of mechanical engineering or engineering mechanics with that of other fields, such as industrial engineering, chemical engineering, materials engineering, and biology, into interdisciplinary programs that will prepare them for further work in the areas of manufacturing, nuclear engineering, energy conversion and conservation, environmental engineering, materials engineering, or biomechanics.

Undergraduates become thoroughly familiar with Lehigh's computer-aided design (CAD) laboratory. The laboratory is a teaching facility and the technology is regarded as an engineering tool that can be applied to solving a wide variety of problems. Undergraduates not only use CAD in their coursework but some have developed interactive tutorials that help fellow students expand on and clarify material presented in class.

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 design, 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 24 credits of humanities/social sciences (page 33), two free electives and four approved electives. The total graduation requirement is 132 credits.

**Undergraduate Curriculum in Mechanical Engineering**

**freshman year (see page 49)**

**sophomore year, first semester** (16 credit hours)
- Math 23 Analytic Geometry & Calculus III (4)
- Mech 2 Elementary Engineering Mechanics (3)
- Phy 21, 22 Introductory Physics II and Laboratory (5)
- ME 10 Graphics for Engineering Design (4)

**sophomore year, second semester** (16 credit hours)
- Math 205 Linear Methods (3)
- ME 104 Thermodynamics I (3)
- Mech 12 Strength of Materials (3)
- ME 21 Mechanical Engineering Lab I (1)
- Mat 33 Engineering Materials and Processes (3)
- Eco 11 Principles of Microeconomics (3) or
- Eco 12 Principles of Macroeconomics (3)

**junior year, first semester** (18 credit hours)
- Mech 102 Dynamics (3)
- ME 205 Thermodynamics II (3)
- ME 231 Fluid Mechanics (3)
- ECE 81 Principles of Electrical Engineering (4)
- ME 111 Professional Development (1)
- ME 121 Mechanical Engineering Lab II (1)
- HSS Humanities/Social Sciences (3)

**junior year, second semester** (18 credits)
- ME 101 Mechanical Engineering Design I (2)
- ME 252 Mechanical Elements (3)
- ECE 162 Electrical Laboratory (1)
- ME 240 Manufacturing (3)
- ME 242 Mechanical Vibrations (3)
- Math 208 Complex Variables (3) or
- Math 231 Probability and Statistics (3)
- HSS Humanities/Social Sciences (3)

**senior year, first semester** (16 credit hours)
- ME 207 Mechanical Engineering Laboratories III (2)
- ME 201 Mechanical Engineering Design II (2)
- ME 321 Introduction to Heat Transfer (3) or
- approved elective (3)
- HSS Humanities/Social Sciences (3) or
- free elective (3)*

**senior year, second semester** (17 credit hours)
- ME 208 Mechanical Engineering Lab IV (2) or
- ME 210 Laboratory Projects (2)
- approved electives (9)
- HSS Humanities/Social Sciences (3)
- free elective (3)*

*Please refer to description of free electives, page 45.

Twelve credits of APPROVED ELECTIVES must be taken according to the following distribution.

At least one course (3 credits) from the following list of engineering science electives:
- ME 322 Gas Dynamics (3)
- ME 331 Advanced Fluid Mechanics (3)
- ME 343 Control Systems (3)
- Mech 302 Advanced Dynamics (3)
- Mech 305 Advanced Mechanics of Materials (3)

At least two courses (6 credits) from the following list of elective courses having design or manufacturing content:
- ME 310 Directed Study (1-3)
- ME 312 Synthesis of Mechanisms (3)
- ME 323 Reciprocating and Centrifugal Engines (3)
- ME 340 Advanced Mechanical Design (3)
- ME 341 Mechanical Systems (3)
- ME 342 Dynamics of Engineering Systems (3)
- ME 345 Fluid Power (3)
- ME 348 Computer-Aided Design (3)
- ME 360 Nuclear Reactor Engineering (3)
- Mech 312 Finite Element Analysis (3)

Any design or manufacturing course taken outside of Mechanical Engineering must be approved by the student's advisor.

Other approved elective courses in the Department of Mechanical Engineering and Mechanics are:
- ME 387 Digital Control (3)
- Mech 307 Mechanics of Continua (3)
- Mech 313 Fracture Mechanics (3)
- Mech 326 Aerodynamics (3)

**Undergraduate Courses in Mechanical Engineering**

**ME 10. Graphics for Engineering Design (4)**
Graphical description of mechanical engineering design for visualization and communication by freehand sketching, production drawings, and 3-D solid geometric representation. Creation, storage, and manipulation of such graphical descriptions using state-of-the-art, commercially available, computer-aided engineering software. Introduction to design process through design projects. Geometrical design consideration of various manufacturing processes. Lectures and laboratory. (ES 2), (ED 2)

**ME 21. Mechanical Engineering Laboratory I (1)**

Laboratory methods employed in mechanical engineering and mechanics. Planning and execution of experiments, analysis of data, and writing of reports. Introduction to elementary instrumentation. Prerequisite: Mech 12, previously or concurrently. (ES 1), (ED 0)

ME 101. Mechanical Engineering Design I (2) spring
Industry-based design projects. Design methodology, feasibility study of design alternatives, and written communications. Prerequisites: ME 10, Mech 12, ME 104. (ES 0), (ED 2)

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 probability. Properties of pure substances and thermodynamic cycles. Corequisites: Math 23 and Phys 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 lecture courses. Includes proposal writing and interpretation of results. Prerequisites: ME 21 and ME 104. (ES 1), (ED 0)

ME 201. Mechanical Engineering Design II (2) fall
Industry-based design projects continued from ME 101. Design, analysis, and simulation by student teams. Fabrication, assembly, and testing of prototypes when practical. Oral and written reports required. Prerequisite: ME 101 and ME 252. (ME 252 may be taken concurrently). (ES 0), (ED 2)

ME 205. Thermodynamics II (3) fall, spring

ME 207. Mechanical Engineering Laboratories 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 Laboratories 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 chairperson. (ES 0.5), (ED 1.5)

ME 231. Fluid Mechanics (3) fall, spring
Kinematics of fluid flow and similarity concepts. Equations of incompressible fluid flow with inviscid and viscous 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 Vibrations (3) fall, spring
Physical modeling of vibrating systems. Linearization. Free and forced single and multiple degree of freedom systems. Simple continuous systems. Engineering applications. Prerequisites: Mech 102, Math 205. (ES 2), (ED 1)

ME 252. Mechanical Elements (3) fall, spring
Methods for the analysis and 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 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 chairperson. (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. (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 radiation. Thermal design of engineering processes and systems. Prerequisites: ME 104, ME 231. Neti, Blythe, Levy. (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 205. (ES 2.5), (ED 0.5)

ME 331. Advanced Fluid Mechanics (3) fall

Separation of flow. Steady and unsteady stall. Secondary flows. Hydrodynamic lubrication. Measurement techniques. Prerequisite: ME 231 or equivalent. Rockwell, C. Smith. (ES 2.5), (ED 0.5)

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. (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
Steady-state and dynamic analysis of mechanical, electromechanical, fluid and thermal engineering systems with emphasis on the modeling process. 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. Johnson. (ES 2), (ED 1)

ME 345. Fluid Power (3) fall
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 1-hour lectures and 2-hour lab per week. Prerequisites: ME 10, ME 252, ME 242. Lucas, Ochs, Ozsoy. (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 chairperson. (ES 1), (ED 2)

ME 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 Physical Science. Neti. (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; 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. Luyben. (ES 3), (ED 0)

ME 389. (ECE 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 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. (ES 1), (ED 1)

Graduate Programs in Mechanical Engineering
The department offers programs of study leading to the degrees of master of science, master of engineering, and doctor of philosophy in Mechanical Engineering.

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.

Subject to approval, courses from other engineering curricula, such as mechanics, materials science and engineering, and chemical, electrical, and industrial engineering, may be included in the major.

A student who plans to work for the doctorate should submit a general plan to the department chairperson during the first year and arrange for the qualifying examinations.

Master of Science
The M.S. Degree program provides students with opportunities for more in-depth studies of mechanical engineering and a broader background in related subject areas. Breadth is ensured through a series of required (three of four) core courses (ME 423, ME 430, Mech 425 and Mech 408) and depth through selected electives in the student's area of interest.

A thesis option and a non-thesis option are offered. The thesis option is for students who desire to enhance their capabilities in mechanical engineering 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 through a concentrated course of study, and requires two three-credit-hour graduate courses in lieu of the thesis. It is possible to complete the degree in one year.

Doctor of Philosophy
Candidacy for the Ph.D. degree follows passing of the qualifying examinations, which also emphasize broad grasp of fundamentals, and forming 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.

The department has a wide range of state-of-the-art computational and experimental systems. Computers include Starnet and Kabota Titan mini-supercomputers, eleven IBM RS-6000 workstations, fifteen Hewlett-Packard workstations, and eight Silicon Graphics workstations. In addition, the University supports networks of hundreds of PC's and other microcomputers and workstations. Experimental facilities include eleven pulsed and continuous laser units for laser diagnostics in the areas of fluid and solid mechanics, four image processing systems, 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 failure of materials in extreme environments, 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.

Some of the recent research activities are listed below:

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; cyclic analysis applied to coal gasifiers; control optimization of heat pumps; laser-Doppler and particle velocimetry; liquid crystal sensors for heat transfer; Raman spectral techniques applied to two-phase flow; laser diagnostics and image processing of complex flow and heat transfer systems.

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) focusing on 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 overland vehicles; conceptualization and hardware development of innovative components and systems for fluid power control; application of robotics to manufacturing; computer-controlled theater lighting design.

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) fall**
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, lamina 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

**ME 413. Numerical Methods in Mechanical Engineering (3)**

**ME 415. Flow-Induced Vibrations (3)**

**ME 420. Advanced Thermodynamics (3) spring**

**ME 423. Heat and Mass Transfer (3) spring**
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

**ME 421. Topics in Thermodynamics (3)**
Emphasis on theoretical and experimental treatment of combustion processes including dissociation, flame temperature calculations, 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 424. Turbulent Flow (3) fall**
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) spring**
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. Staff

**ME 427. (ChE 427) Multiphase Heat Transfer (3) spring**
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) spring**
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, Liakopoulous

ME 430. Advanced Fluid Mechanics (3) Fall
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, circulation theorems, potential flow behavior, irrotational and rotational flows, simple boundary layer flows and solutions, and real fluid flows and consequences. Smith

ME 431. Advanced Gas Dynamics (3)

ME 432. Topics in 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 openloop 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) feedforward 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 engineering. 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. 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. Erdogan, 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 coating Moire 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. Analog, digital and hybrid simulation. 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 chairperson.

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

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 certain 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 6 credits of personal electives in the junior and senior years. Beyond the sophomore year there are 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 either to concentrate on areas such as applied mathematics and computational mechanics, solid mechanics, engineering materials, and fluid mechanics or to obtain further depth in all areas. Each student must select a minimum of 12 credits from the courses listed under options and six additional credits of approved technical electives from this list or from other courses offered in the departments of mathematics, physics or chemistry, or in the college of engineering and applied science. The academic advisor for the Engineering Mechanics program will provide guidance in formulating the student's goals and choosing the electives.

In addition to the required and elective courses in mathematics, sciences and engineering, the B.S. degree program in Engineering Mechanics includes 24 credits of Humanities and Social Sciences (page 45). The total graduation requirement is 131 credits.
Undergraduate Curriculum in Engineering Mechanics

freshman and sophomore years: same as ME curriculum

junior year, first semester (17 credit hours)
Mech 102 Dynamics (3)
ME 231 Fluid Mechanics (3)
ME 121 Mechanical Engineering Lab II (1)
ECE 81 Principles of Electrical Engineering (4)
ME 240 Manufacturing (3)
HSS Humanities/Social Sciences (3)

junior year, second semester (16 credit hours)
ECE 162 Electrical Laboratory (1)
ME 242 Mechanical Vibrations (3)
Math 208 Complex Variables (3)
Math 230 Numerical Methods (3)
HSS Humanities/Social Sciences (3)

Engineering Mechanics elective (3)

senior year, first semester (17 credit hours)
ME 321 Introduction to Heat Transfer (3)
(May be taken concurrently). (ES 3), (ED 0)
ME 207 Mechanical Engineering Laboratories III (2)
ME 210 Laboratory Projects (2)

or

ME 210 Laboratory Projects (2)

HSS Humanities/Social Sciences (3)

Engineering Mechanics elective (3)

senior year, second semester (17 credit hours)
ME 208 Mechanical Engineering Laboratories IV (2) or
ME 210 Laboratory Projects (2)
HSS Humanities/Social Sciences (3)

free elective (3)

Engineering Mechanics electives (6)

Total credits for graduation: 131

Typical recommended options

Applied Mathematics and Computational Mechanics
Math 322 Methods of Applied Analysis I (3)
Math 323 Methods of Applied Analysis II (3)
Mech 305 Advanced Mechanics of Materials (3)
Mech 312 Finite Element Analysis (3)
Math 309 Theory of Probability (3)

Solid Mechanics
Math 322 Methods of Applied Analysis I (3)
Mech 305 Advanced Mechanics of Materials (3)
Mech 312 Finite Element Analysis (3)
Mech 313 Fracture Mechanics (3)
Mech 307 Mechanics of Continua (3)

Engineering Materials
Phy 31 Introduction to Quantum Mechanics (3)

Mat 218 Mechanical Behavior of Materials (3)
Phy 363 Physics of Solids (3)
Mech 305 Advanced Mechanics of Materials (3)

Fluid Mechanics
Math 322 Methods of Applied Analysis I (3)
ME 331 Advanced Fluid Mechanics (3)
Mech 326 Aerodynamics (3)

Engineering Materials
Phy 31 Introduction to Quantum Mechanics (3)
Mat 218 Mechanical Behavior of Materials (3)
Phy 363 Physics of Solids (3)
Mech 305 Advanced Mechanics of Materials (3)

Fluid Mechanics
Math 322 Methods of Applied Analysis I (3)
ME 331 Advanced Fluid Mechanics (3)
Mech 326 Aerodynamics (3)

Undergraduate Courses in Engineering Mechanics

Mach 2. Elementary Engineering Mechanics
(Static equilibrium of particles and rigid bodies; analysis of simple structures; internal forces, stress, strain, and Hooke's Law; statically indeterminate torsion of circular shafts; pure bending of beams. Prerequisites: Math 22 and Phys 11. (Math 22 may be taken concurrently). (ES 3), (ED 0)

Mach 12. Strength of Materials (3)
Mohr's circle for stress; plastic deformation, failure criteria; transverse shearing stresses in beams; deflection analysis of beams; strain energy methods; column buckling; analysis of thick-walled cylinders. Prerequisites: Mach 2 and Math 23. (Math 23 may be taken concurrently). (ES 3), (ED 0)

Mach 102. Dynamics (3) fall, spring
Particle dynamics, work-energy, impulse-momentum, impact, systems of particles; Kinematics of rigid bodies; Kinetics of rigid bodies in plane motion, energy, momentum, eccentric impact. Prerequisites: Mach 2 and Math 23. (ES 3), (ED 0)

Mach 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

Mach 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.

Mech 305. Advanced Mechanics of Materials (3) fall
Strength, stiffness, and stability of objects used in mechanical engineering. Stresses and deformations for problems such as thick-walled cylinders, spinning disks, thermal stresses, contact stresses, curved beams, beam-columns, torsion, pressure vessels, energy methods, and limit analysis. Projects relate analysis to engineering design. Prerequisites: Mech 12, Math 205. (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. Prerequisite: 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 (NISA, ALGOR) are used. In addition, students develop and use their own finite element codes. Applications to design. Prerequisite: Mech 305. Varley. (ES 3), (ED 0.5)

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. Wei. (ES 1.5), (ED 1.5)

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 205. Blythe. (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 chairperson.

Graduate Program in Engineering Mechanics
The department offers programs of study leading to the degrees of master of science, and doctor of philosophy. These graduate degrees are given in Applied Mechanics.

The program is open in general to students who have graduated from a curriculum in engineering mechanics, engineering mathematics, engineering physics, civil engineering, or mechanical engineering at a recognized institution. A student whose background is different from that required in these undergraduate curricula or who has a particular deficiency may be required to present a larger number of credits than the minimum required for graduation.

A student who plans to work for the doctorate should submit a general plan to the department chairperson during the first year and arrange for the qualifying examinations.

Master of Science
The M.S. degree program provides students with opportunities for more in-depth studies of engineering mechanics and a broader background in related subject areas. Breadth is ensured through a series of required (three of four) core courses, and depth, through selected electives in the student's area of interest.

A thesis option and a non-thesis option are offered. The thesis option is for students who desire to enhance their capabilities in engineering 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 engineering mechanics through a concentrated course of study, and requires two three-credit-hour graduate courses in lieu of the thesis.

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 for graduate work in applied mechanics.

Doctor of Philosophy
Candidacy for the Ph.D. degree follows passing of the qualifying examinations, which also emphasize broad grasp of fundamentals, and forming 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.

The department has a wide range of state-of-the-art computational and experimental systems. Computers include Stardent and Kubota Titan mini-supercomputers, eleven IBM RS-6000 workstations, fifteen Hewlett-Packard workstations, and eight Silicon Graphics workstations. In addition, the University supports high-speed networks of hundreds of PC's and other microcomputers and workstations. Experimental facilities include eleven 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.
Thermomechanical and electromechanical interactions, systems; Hamilton's principle; Hamilton's canonical servocontrolled hydraulic testing machines, photoelastic student include the latest mechanical, electromagnetic and shock wave propagation; non-Newtonian flows in flexible structures, strength of structural members and of interfaces. Hydraulic equations; contact transformations; Hamilton-Jacobi partial differential equations, and thermodynamic and constitutive equations in non-linear elasticity. This includes a discussion of the mechanical and thermodynamic bases of the subject, as well as the use of invariance principles in formulating constitutive equations.

Some of the recent research activities are listed below.


**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.

**Theoretical fluid mechanics.** Vortex boundary layer interaction, modeling of turbulent boundary layers; geophysical flows such as frontal systems and ocean 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; magnetofluid mechanics; wing theory; thermally driven flows.

Special departmental facilities of interest to the graduate student include the latest mechanical, electrodynamic and servocontrolled hydraulic testing machines, photoelastic bench, laser, and corrosion fatigue test facilities.

Except for the core courses graduate courses are generally offered every third semester.

**Mech 402. Advanced Analytical Mechanics (3)** fall
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 308 or consent of the department chairperson. Erdogan

**Mech 405. Response of Systems to Random Loads (3)** fall
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 chairperson. 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, S. Johnson

**Mech 407. Wave Propagation in Solids (3)**
Wave propagation in deformable elastic solids; problems in half-space 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)** fall
Kinematics of deformation, analysis of stress, strain-energy function. Reciprocal theorem. Methods for two-dimensional boundary value problems applied to anti-planer, torsion, bending and plane problems. Approximate and numerical methods of solution. Prerequisites: Math 205; Mech 305 or equivalent course in advanced mechanics of material. Erdogan, Hartranft

**Mech 410. Theory of Elasticity II (3)** spring
Advanced topics in the theory of elasticity. The subject matter may vary from year to year and may include, e.g., 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 chairperson. 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.

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. Kalnins, Delph

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 409. Delph

Mech 415. (CE 468) Stability of Elastic Structures (3)

Mech 416. (CE 464) Analysis of Plates and Shells (3) fall
Bending of rectangular and circular plates, plates under lateral loads, plates with thermal and inelastic strains, effect of inplane forces, large deflections, buckling of plates. Geometry and governing equations of shell, shells of revolution, membrane states, edge solutions, solution by numerical integration, non-symmetric problems, buckling of shells, applications to pressure vessels. Prerequisites: Math; 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) fall
Finite element approximations to the solutions of differential equations of engineering interest are developed from variational principles or by Galerkin's method. Linear and nonlinear example 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 FORTRAN. Delph

Mech 419. (CE 419) Asymptotic Methods in the Engineering Sciences (3)

Mech 421. Fluid Mechanics (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: Mech 421. Salathe, Blythe

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) spring
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 about one-third of the course. There is a brief treatment of advanced impact. Use of symbolic computer codes is encouraged. Johnson

Mech 490. Thesis
Mech 499. Dissertation

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 221, or Met 320; Met 317, or consent of the department chairperson. Chou, Wei

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)

Engineering Mathematics Courses
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 chairman. Staff

EMA 490. Thesis
EMA 499. Dissertation

Military Science

Professor. LTC Robert W. Wolfenden, M.A. (Providence College), chairperson.
Assistant professors. MAJ Ralph J. Gabriel, M.S. (Lehigh); CPT Steven Nott, B.A. (University of Wisconsin); CPT John O'Brien, B.S. (U.S. Military Academy); CPT Jonathan Scott, B.A. (University of Alabama).
Instructors. MSG Larry D. Byrns; SFC Ross Corbett; SFC Rafael Galzarza; SFC Ronald D. Stokes.

The Department of Military Science, established in 1919, conducts the Army Reserve Officer 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 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 Science 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 advisers. 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.

There are many opportunities for advanced military and civilian schooling beginning with nearly three months of training in the branch specialty. A person may later receive an additional specialty in such areas as systems analysis, research and development, foreign area specialization, comptroller, or public affairs. Students selected for reserve forces duty are provided with the opportunity to maintain the options of a military or civilian career upon completion of the program. Those individuals who receive reserve forces duty become officers in the Army Reserve or Army National Guard in their hometown area and essentially have a part-time military career. Active duty officers are assigned at various locations throughout the world. An officer can earn retirement through both programs after twenty years of service.

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 $12,000 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 August 15th prior to the senior year for early selection, but no later than December 1st 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 six-week basic ROTC summer camp and have two years of undergraduate or graduate studies remaining. The student is paid for the six-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 most outdoor activities such as orienteering, patrolling, and survival training. Fort Indiantown Gap Military Reservation, located east of Harrisburg, Pa., and Fort Dix, N.J., 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), and Northern Warfare School (Fort Greely, Alaska). This off-campus program is fully funded by the U.S. Army. Many other installations may be visited through the Cadet Troop Leader Training programs.

Minor in Military Science. A minor in Military Science is available in the College of Arts and Science. 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:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>MS 101</td>
<td>Advanced Military Skills (3)</td>
</tr>
<tr>
<td>MS 102</td>
<td>Advanced Leadership (3)</td>
</tr>
<tr>
<td>MS 113</td>
<td>Military Command and Staff (3)</td>
</tr>
<tr>
<td>MS 114</td>
<td>Officer Responsibilities, Ethics and Military Professionalism (3)</td>
</tr>
<tr>
<td>MS 118</td>
<td>Special Military Topics (1)</td>
</tr>
<tr>
<td>Hist 310</td>
<td>American Military History (3)</td>
</tr>
</tbody>
</table>

International Relations (3) (Select one course from one of the following categories)
- International Relations
- Government

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 Monday afternoons. 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.

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 and one field trip.

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.

23. Topographic Analysis and Land Navigation (2) fall
Maps as tools in basic terrain analysis and as navigational aids. Emphasis on application and field exercises at individual and small group levels. Includes laboratory and FTX.

24. Leadership Theory and Management (2) spring
Contemporary theories, traits and principles. Leadership philosophies, communications, leader-follower relationships, and leadership problem-solving. Leadership simulations. Includes laboratory and FTX.

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 chairman.

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 5 day leadership exercise. Prerequisite: permission of department chairman.
Advanced ROTC Summer Camp
This is a six-week training program normally conducted at Fort Bragg, NC. 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 engineering curricula, may be used to fulfill the industrial employment requirements of the engineering courses, CE 100, IE 100, and Mat 100. Nursing students spend two weeks field training and four weeks clinical training in an Army hospital.

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 chairman.

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 chairman.

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 the department chairman.

Modern Foreign Languages
Professors. Lenora D. Wolfgang, Ph.D. (Pennsylvania), French.
Associate professors. Marie-Sophie Armstrong, Ph.D. (Oregon), French; Marie-Helene Chabut, Ph.D. (U.C. San Diego), French; Linda S. Lefkowitz, Ph.D. (Princeton), Spanish; Mary Nicholas, Ph.D. (Pennsylvania), Russian; David W. Pankenier, Ph.D. (Stanford), Chairperson, Chinese; Antonio Prieto, Ph.D. (Princeton), Spanish; D. Alexander Waldenfuss, Ph.D. (Berkeley), German.
Assistant professors. Constance Cook, Ph.D. (Berkeley), Chinese; Edward E. Manouelian, Ph.D. (Harvard), Russian; Jean M. O’Bryan-Knight, Ph.D. (Michigan), Spanish; Vera Stegmann, Ph.D. (Indiana) German.

Languages shown above in italics indicate the language normally taught by that faculty member. Command of languages opens the door to other cultures, traditions, and modes of thought and also promotes deeper insight into one’s native language. Knowledge of languages is increasingly indispensable in a broad range of professions such as journalism, government, international relations, law, the armed forces, and international business. A bachelor of arts degree with a major in languages can be a stepping stone to fields such as law, international careers, and business. Proficiency in foreign languages is often required for graduate study and for research in science and technology. Language skills are both personally enriching and enhance 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 House, and 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 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
Requirements for the B.A. and B.S. in chemistry include German (preferred), French or Russian (see page 33). The honors major in international relations requires foreign language study. The College Scholar program in the College of Arts and Science; 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 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 foreign languages.

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 chairperson. 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 French, German, 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.

**Minor programs.** The department offers minor programs in Chinese, French, Russian, and Spanish and coordinates these studies with a student’s major requirements in any college.

**Related programs.** These are available in Asian Studies, Foreign Careers, Jewish Studies, Latin American Studies, and Russian and Soviet Studies.

**Language of instruction.** All courses are taught in the target language except MFL courses listed under "Foreign Culture and Literature Taught in English" page 212. Students are thereby 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. These courses have no prerequisite and may, in most cases, be taken to fulfill preliminary distribution requirements. One of these courses may be included in the major, listed under "Foreign Culture and Literature Taught in English", page 212.

**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 (see p. 312). 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 March 15 for summer or fall. For credit, transfer students must consult in advance with their major adviser, foreign language adviser, other appropriate departments, the Office of International Education and when appropriate, the Office of Financial Aid.

A selective program of foreign summer internships is being developed. Lehigh programs for summer study in China and Russia are regularly offered.

Lehigh offers summer programs through the Lehigh Valley Association of Independent Colleges (LVAIC). 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-LVAIC Center for Jewish Studies include Hebrew in Israel (see page 37).

Credits and grades are fully transferable under normal LVAIC cross-registration procedures. Interested students should consult with the department of Modern Foreign Languages, Maginnes Hall.

**Campus foreign language house.** The International House is an important feature of campus life. Students are encouraged to participate in weekly open dinners and to consider living there.

**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 take one course taught in English by the department for credit toward a major requirement. Interested students should consult their language major advisers.

**MFL 23. Lehigh in Russia (1-6)**

A summer program in Russia, taught in English. (ND)

**MFL 24. The Empire of the Tsar: A Journey Through 19th-Century Russia (3)**

Classics of 19th-century Russia; contemporary essays and autobiographical writing; fiction. (HU)

**MFL 25. Heretics and Madmen of 20th-Century Russia (3)**

Major figures of 20th-century Russian literature. Heresy, dissent, and censorship, and the position of the artist in a totalitarian society; major intellectual and artistic trends of the century; Russia’s intense interaction, borrowing, and influence on the West. (ND)

**MFL 26. The Decadent Imagination in Russian Literature: 1890-1915 (3)**

Poetry, fiction, and drama of Russian symbolism and other related avant-gardisms of the end of the 19th century in the context of contemporary European influences. (ND)

**MFL 27. Russian Classics (3)**

Russian classics in translation. (HU)

**MFL 43. German Literature in Translation (3)**

One period or theme in German literature. (ND)

**MFL 51. Contemporary Hispanic-American Literature (3)**

Reading and discussion of distinguished Latin American writers: Borges, Garcia Marquez, Cortazar and Vargas Llosa. (ND)

**MFL 53. The Hispanic World and Its Culture (3)**

Characteristics and values of the people of Spain and Latin America in literary works and other material. Hispanic cultural contributions to Western civilization. (ND)
MFL 72. (ASIA 72) Chinese Literature in Translation (3)
Survey of a major genre of Chinese literature from earliest times through the modern period. May be repeated for credit as topic varies. (HU)

MFL 73. (ASIA 73) Introduction to Chinese Culture (3)
Traditional Chinese attitudes, values, and patterns of social interaction from a modern perspective. (ND)

MFL 74. (ASIA 74) Chinese Cultural Program (1-6)
A summer program in China, taught in English. (ND)

MFL 75. (ASIA 75) (Hist 75) Chinese Civilization (3)
Traditional Chinese customs, beliefs, values, and institutions and their influence outside China. Thought, literature, and the arts in the imperial age from a historical perspective. (HU)

MFL 140. (CogS 140, Anth 140) Introduction to Descriptive Linguistics (3)
Relationship between language and mind; formal properties of language; language and society; how languages change over time. (SS)

MFL 173. The Literature of the Americas (3)
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. (ND)

MFL 204. (Rel 204) The Myths of the Slavs: Folklore and Literature (3)
Distinction between "folklore" and "literature". Study of Russian, Ukrainian, and Belarusian tales, legends, riddles, sayings, and heroic poems. (HU)

MFL 259. (Hist 259) Intellectual and Cultural History of Medieval Russia (3)
Survey of medieval Russian history from the eleventh to the late seventeenth century. Historical works on the period, early Russian epics, chronicles, legends, saints' lives, sermons, folk poetry, and Russian picaresque tales. Development of art and architecture. Manouelian. (SS)

Chinese

Preliminary courses. These may be replaced by advanced standing for students who qualify.
Chinese 1 Elementary Chinese I (4)
Chinese 2 Elementary Chinese II (4)
Chinese 11 Intermediate Chinese I (3)
Chinese 12 Intermediate Chinese II (3)

Requirements for the minor. A minimum of seventeen credit hours selected from Chinese 1 through 291. Not more than one MFL series course taught in English may be included. For Asian Studies major and minor, see page 117.

Undergraduate Courses 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 1; more vocabulary and sentence patterns, reading and writing Chinese characters. Weekly video laboratory and conversation practice. Prerequisite: Chin 1 or equivalent. (HU)

Chin 11. Intermediate Chinese I (3) fall
Advanced character texts and vocabulary; folktales, brief readings in Chinese. Weekly laboratory and conversation practice. Prerequisite: Chin 2 or equivalent. (HU)

Chin 12. Intermediate Chinese II (3) spring
Continuation of Chin 11; oral and written exercises. Weekly laboratory and conversation practice. Prerequisite: Chin 11 or equivalent. (HU)

Chin 41. Modern Written Chinese I (1-3) 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 (1-3) spring
Continuation of Chin 41. Prerequisite: Chin 11, Chin 41, or equivalent and consent of the instructor. (HU)

Chin 141. Advanced Chinese I (3) 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 (3) spring
Continuation of Chin 141; more advanced readings, conversation and composition. Prerequisite: Chin 141 or equivalent. (HU)

Chin 151. Chinese Short Fiction (3)
Reading of modern and contemporary short stories, essays, anecdotal literature, and other authentic texts as points of departure for conversation practice and composition. Prerequisite Chin 142 or the equivalent, or consent of the instructor. (HU)

Chin 251. Special Topics (1-3)
Literary and linguistic topics not covered in regular courses. May be repeated for credit. Prerequisite: consent of the instructor. (HU)

Chin 371. Special Topics (1-3)
Directed study of an author, genre, or period not covered in regular courses. May be repeated for credit. Prerequisite: consent of the instructor.

French
Preliminary courses. These may be replaced by advanced standing for students who qualify.
- Fren 1 Elementary French I (4)
- Fren 2 Elementary French II (4)
- Fren 11 Intermediate French I (3)
- Fren 12 Intermediate French II (3)

Requirements for the major. A minimum of thirty credit hours is required beyond Fren 12 as follows:
- Fren 143 and 144, Advanced Oral and Written French (6)
- Fren 151 and 152, Survey of Literature (6)
- Two or three courses from the following: Fren 146, 159, 181, 191, or any course at the 200 level (6-9).
- Three or four courses at the 300 level (9-12).

Requirements for the departmental honors major. Thirty-six credit hours are needed. Requirements are the same as for the major, plus six additional hours of advanced study on a literary or cultural subject normally taken as an honors thesis (Fren 371) and a 3.20 average in the major.

Recommended related courses. Students majoring in French are urged to take elective courses on related subjects, either within or outside the department, as approved by their adviser.

Requirements for the minor. Fifteen credit hours are required above Fren 12 as follows:
- Fren 143 (3)
- Two or three of 144, 146, 151, 152, 159, 181, 191, or any course at the 200 level (6-9).
- One or two courses at 300 level (3-6).

Requirements for advanced courses. Except where otherwise noted, 200- or 300-level courses are open to students having completed six credit hours of French beyond Fren 12. Exceptions require the consent of the instructor.

Study Abroad. A period of study in a French-speaking country is strongly encouraged for qualifying students. Agreements are in effect with Paul Valéry University, Montpellier, and Ecole Supérieure de Commerce, Poitiers. For these and LVAIC summer programs, both grades and credits are transferred. For other approved programs, consult the Office of International Education.

Undergraduate Courses in French
Fren 1. Elementary French I (4) fall
Basic conversational French, illustrating essential grammatical principles, reading simple texts and writing. Language laboratory video.

Fren 2. Elementary French II (4) spring
Continuation of Fren 1. Prerequisite: Fren 1 or appropriate Achievement Test score before entrance, or consent of instructor. (HU)

Fren 11. Intermediate French I (3) fall
Completion of grammar and grammar review. Video, readings, and discussion. Prerequisite: Fren 2 or appropriate Achievement Test score before entrance, or consent of instructor. (HU)

Fren 12. Intermediate French II (3) spring
Readings and discussion. Prerequisite: Fren 11 or appropriate Achievement Test score before entrance, or consent of instructor. (HU)

Fren 41. French Pronunciation (1)
Correct pronunciation of French: the obstacles commonly encountered by American speakers. Articulation, rhythm and pitch. Introduction to the International Phonetic Alphabet. Laboratory work. Prerequisite: any French course previously or concurrently. (HU)

Fren 42. Grammar (1)
Intensive review of the fundamentals of French grammar. Prerequisite: Equivalent of Fren 2. May be taken for credit only if no previous degree credit in French has been granted; may be audited by others. (HU)

For Advanced Undergraduates And Graduate Students
Fren 143. Advanced Written French (3)
Intensive practice in written French and introduction to literary criticism. Prerequisite: Fren 12, or Achievement Test score of 590 or consent of instructor. (HU)

Fren 144. Advanced Oral French (3)
Emphasis on oral work. Prerequisite: Fren 12, or Achievement Test score of 590 or consent of instructor. (HU)

Fren 146. French for Business and Foreign Careers (3)
For students who want "professional" French but are uncertain of their readiness for highly specialized material. Intensive review of grammar, reading of simple contemporary texts, conversation, composition, and letter writing. Prerequisite: Fren 12 or consent of instructor. (HU)

Fren 151. Survey of French Literature I (3)
From the Middle Ages through the 18th century. Prerequisite: Fren 143 or 144 or consent of instructor. Wolfgang. (HU)

Fren 152. Survey of French Literature II (3)
Representative works of the 19th and 20th centuries. Prerequisite: Fren 143 or 144, or consent of instructor. Armstrong. (HU)
Fren 159. The French-Speaking World and Its Culture (3)
Cultural, social, and artistic development of France and the French-speaking world. Prerequisite: Fren 143 or 144, or consent of instructor. Armstrong, Chabut. (HU)

Fren 181. French Cultural Program (1-6)
A summer program abroad. Formal instruction in the French language and direct contact with the people and their culture during one or two months in a French-speaking country. (For LVAIC courses, see Fren 191, 291 below.) (HU)

Fren 223. Love and the French Novel (3)
Representative works from each period of French literature from Tristan et Iseult and La Princesse de Clèves to Gide's L'Immoraliste. Style, themes, myths and story patterns are analyzed. Prerequisite: any of Fren 143, 144, 151, 152, or 159. Wolfgang. (HU)

Fren 224. Great French Plays (3)
Evolution of French drama through study of master works from the 17th century to the present. Prerequisite: any of Fren 143, 144, 151, 152, or 159. (HU)

Fren 268. World Literature Written in French (3)
Major authors from areas outside Europe, such as Canada, Africa, and the Caribbean. Prerequisite: any of Fren 143, 144, 151, 152, or 159. (HU)

Fren 271. Readings (3)
Study of the works of some author or group of authors or a period, or of a literary theme. May be repeated once for credit. Prerequisite: Fren 143 or 144, plus 151, or 152, or consent of instructor. (HU)

Fren 281. French Cultural Program (1-6)
A program in a French-speaking country offering formal language courses and cultural opportunities. (For LVAIC courses, see Fren 291 below.) Prerequisite: consent of instructor. (HU)

Fren 301. Advanced Composition and Translation (3)
Techniques of translation. Literary, political, and technical texts. Essay-writing techniques and free composition. Prerequisite: a 200-level course or consent of instructor. (HU)

Fren 302. Medieval French Literature (3)
Introduction to Old French from La Chanson de Roland to François Villon. Wolfgang. (HU)

Fren 303. Arthurian Romances (3)

Fren 304. Renaissance Poetry (3)
Study of the major poets of the period, including Ronsard and du Bellay. Wolfgang. (HU)

Fren 305. Prose in the 16th Century (3)
Analysis of fiction, memoirs, historical documents, including the works of Rabelais, Montaigne, and Marguerite de Navarre. Wolfgang. (HU)

Fren 311. French Classicism (3)
French classical theater, novel, and criticism, with emphasis on Corneille, Racine, Molière, Pascal, Lafayette, Malherbe, and Boileau. Chabut. (HU)

Fren 313. The Age of Enlightenment (3)
The Philosophes and Encyclopédistes of the 18th century, with emphasis on Voltaire, Rousseau, Montesquieu, and Diderot. Chabut. (HU)

Fren 315. 19th Century Poetry (3)
Parmassian, Symbolist, and Post-Symbolist eras. (HU)

Fren 317. The Romantic Movement (3)
The Romantic movement in France with readings from its principal exponents. (HU)

Fren 318. Drama in the Twentieth Century (3)
Contemporary French drama with an analysis of its origins and movements. Armstrong. (HU)

Fren 319. Twentieth Century Novel and Poetry (3)
Detailed study of representative major works. Armstrong (HU)

Fren 320. Contemporary French Fiction (3)
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 (3)
Examination, within the framework of short fiction (tales, short stories, and short novels), the major literary currents which have made up twentieth-century literature, exploring works by Camus, Cocteau, Gracq, Peiry de Mandiargues, Robbe-Grillet, Sarraute, Sartre, and others. Instruction in French. Armstrong. (HU)

Fren 345. Advanced French for Business and Foreign Careers (3)
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). Prerequisite: any of Fren 143, 144, 146, 159, or consent of instructor. (HU)

Fren 369. Readings (3)
Advanced study of an author, period, or theme. Topics vary. May be repeated once for credit. (HU)

**Fren 370. Internship (1-6)**
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. Prerequisites: French 143 or 144, and approval of French study abroad advisor. (HU)

**Fren 371. Independent Study (1-6)**
Special topics under faculty guidance, including honors thesis. May be repeated once for credit. Prerequisite: consent of instructor. (HU)

**German**

**Preliminary courses.** These may be replaced by other courses when a student qualifies for advanced standing.

- Germ 1: Elementary German I (3)
- Germ 2: Elementary German II (3)
- Germ 11: Intermediate German I (3)
- Germ 12: Intermediate German II (3)

**Requirements for the major.** A minimum of thirty credits beyond Germ 12 of which three credits must be a junior year writing course in the German section. Emphasis should be upon 200- and 300-level courses.

**Requirements for the departmental honors major.**
Requirements are the same as for the major, plus: two additional advanced courses at the 300 level; dissertation or comprehensive examination (written or oral); a 3.2 G.P.A. in courses in the major.

**Recommended related courses.** Students majoring in German are urged to take courses on related subjects, either within or outside the department, as approved by their advisor.

**Requirements for the minor.** Fifteen credits above Germ 12 are required including at least one at 300-level.

**Requirements for advanced courses.** The prerequisite for all 200-level courses is at least one three-credit course taught in German beyond Germ 12 or equivalent. The prerequisite for all 300-level courses is at least two three-credit courses beyond Germ 12 (course in English excluded) or equivalent. Prerequisite may be waived by consent of the chairperson.

**Undergraduate Courses in German**

**Germ 1. Elementary German I (4)**
Fundamentals of German; reading of 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 (3)**
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 (3)**
Continuation of Germ 11. Prerequisite: Germ 11 or consent of instructor. (HU)

**Germ 81. German Cultural Program (1-6)**
Summer program abroad. Formal instruction in the language and the culture of a German speaking country. (HU)

**Germ 163. Introduction to German Culture (3)**
Lectures, readings, and discussion of selected aspects of German culture. Prerequisite: Germ 12 or equivalent, or consent of instructor. (HU)

**Germ 165. Introduction to the German Literary Tradition (3)**
Representative works from one or more of the major periods of German literature. Prerequisite: Germ 12 or equivalent, or consent of instructor. (HU)

**Germ 167. Conversation and Composition (3)**
Intensive practice in oral and written German. Prerequisite: Germ 12 or equivalent, or consent of instructor. (HU)

**Germ 169. Business German**
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 12 or equivalent, or consent of instructor. (HU)

**For Advanced Undergraduates And Graduate Students**

**Germ 201. Survey of German Literature I (3)**
German literature to the second half of the 18th century. Readings, literature, and discussion of representative works. (HU)

**Germ 202. Survey of German Literature II (3)**
From the Age of Goethe to the present. Readings, lectures, and discussion of representative works. (HU)

**Germ 211. Introduction to German Drama (3)**
Drama as a literary genre; plays from various periods of German Literature. (HU)
Germ 214. Goethe's "Faust" (3)
Study of Goethe's play with an introduction to the Faust tradition. (HU)

Germ 231. New German Cinema (3)
Oral discussion and written analysis of selected films. (HU)

Germ 241. Advanced Composition and Conversation (3)
Practice in writing and speaking in German. (HU)

Germ 250. Special Topics (1-3)
Literary and linguistic topics not covered in regular courses. May be repeated for credit. (HU)

Germ 281. German Cultural Program (1-6)
Study abroad. Formal instruction in German and direct contact with the people and their 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 (3)
Writers and literary movements from the end of the Middle Ages through the Baroque. (HU)

Germ 303. German Romanticism (3)
Early and late romanticists. (HU)

Germ 305. 20th-Century German Literature (3)
Topics in German literature of the 20th century. (HU)

Germ 315. Translation and Stylistics (3)
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. (HU)

Germ 320. Berlin in the Twenties (3)
Literature and culture of the Weimar Republic. (HU)

Germ 325. 19th-Century German Literature (3)
Representative writers of post-Romanticism. (HU)

Germ 341. Advanced Phonetics, Linguistics, Composition, Conversation and Translation (3)
Essay writing and translation from and into German. (HU)

Germ 344. The Age of Enlightenment and Classicism (3)
Selected works of the period. (HU)

Germ 350. Special Topics (1-3)

Literary or linguistic topics not covered in regular courses. May be repeated for credit. Prerequisite: permission of the instructor. (HU)

Germ 370. Internship (1-6)
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)

Hebrew
The department offers courses both separately and in the context of the Jewish Studies minor (see page 37).

Hebr 1. Elementary Modern Hebrew I (3) 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 (3) 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 (3) 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 (3) 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. (HU)
Japanese
For Asian Studies major and minor, see page 117.

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 (3) 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 (3) spring
Continuation of Japanese 11. Prerequisite: Japanese 11 or equivalent. (HU)

Jpns 141. Advanced Japanese I (3) fall
Advanced reading and oral comprehension. Conversation and writing practice. Prerequisite: Jpns 12 or equivalent. (HU)

Jpns 142. Advanced Japanese II (3) spring
Continuation of Jpns 141. Prerequisite: Jpns 141 or equivalent. (HU)

Jpns 296. Special Topics (1-3)
Literary or linguistics topics not covered in regular courses. May be repeated for credit. Prerequisite: consent of instructor. (HU)

Russian
Requirements for minor. Eighteen credit hours of Russian are required not including MFL 21, 22, 321 or 322. For Russian studies major and minor, see page 337.

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 (3) 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 (3) spring
Continuation of Russ 11. Prerequisite: Russ 2 or 11, or equivalent. (HU)

Russ 141. Conversation and Composition I (3) fall
Intensive practice in oral and written Russian; laboratory practice in aural 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 (3) spring
Continuation of Russ 141. Prerequisite: Russ 141. (HU)

Russ 215. Russian Classics: Russian Literature with Variable Topic and Credit (3-4)

Russ 221. The Emergence of Russian Fiction: The 19th Century (3)
Development of genre; the role of the reader; symbolic significance of the fictional space each author creates, from the claustrophobic slums of Petersburg to the endless reaches of the steppe. Readings include Pushkin's Eugene Onegin, Lermontov's A Hero of Our Time, Gogol's Dead Souls, and Dostoevsky's White Nights. (HU)

Russ 231. Russian in the Real World I (3)
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 (3)
A continuation of Russ 231. (HU)

Russ 241. The End of the Empire: Russian Literature Since 1985 (3)
Recent developments in Russian fiction. Trends in the pictorial arts, film, prose and poetry. (HU)

Russ 251. Special Topics (3) fall
Intensive study of literary or linguistic topics. Prerequisite: Russ 142. May be repeated for credit. Nicholas. (HU)

Russ 252. Special Topics (3) spring
Intensive study of literary or linguistic topics. Prerequisite: Russ 142 or 251. May be repeated for credit. Nicholas. (HU)

Russ 311. Utopia in Power: Russian Literature after the Revolution (3)
Innovative Russian writers of the 1920's. Themes and techniques developed by writers to deal with the problems of society after the revolution of 1917. (HU)

Russ 370. Internship (1-6)
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 (1-3)**
Independent study or 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: undergraduate degree and consent of instructor. Nicholas. (HU)

**Spanish**

**Preliminary courses.** These may be replaced by other courses if students achieve advanced standing.

- **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 (3)**
  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. Prerequisite: Span 2 or equivalent. (HU)

- **Span 12. Intermediate Spanish II (3) 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. (HU)

- **Span 131. Communicating in Spanish for Medical Personnel (1-3)**
  For prospective medical personnel communicating with Spanish-speaking patients. Dialogues, health-care vocabulary. Review of grammar. Language laboratory practice. Prerequisite: Span 12 or equivalent. Lefkowitz (HU)

- **Span 133. Phonetics and Pronunciation (3)**
  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 (3) fall**
  Intensive review of Spanish grammar with stress on finer points. Analysis of syntax and style. Prerequisite: Span 12 or equivalent. Staff. (HU)

- **Span 142. Advanced Conversational Spanish (3) 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 of Spain (3) 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. Lefkowitz. (HU)

- **Span 152. Cultural Evolution of Latin America (3)**
  The historical and cultural evolution of Latin America. Discussion of representative literary works in their cultural and historical contexts. Prerequisite: Span. (HU)

- **Span 199. Special Topics (3)**
  For students who take a course, not offered by 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 (3)
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. Lefkowitz. (HU)

Span 212. Writing Skills (3)
Improving writing proficiency through practice in composition and translation. Prerequisite: Span 141 or equivalent. Lefkowitz. (HU)

Span 231. Spanish American Literature (3)
Literature of the pre-Colombian, conquest, and colonial periods. Oral and written reports. Prerequisite: Span 151 or 152. (HU)

Span 263. The Spanish American Short Story (3)
Comparative study of the literary problems posed by the work of significant short-story writers such as Quiroga, Borges, Cortázar, Ribeyro, and others. Prerequisite: Span 152. Prieto or O'Bryan. (HU)

Span 265. Spanish and Latin American Cinema (3)
Oral discussion and written analysis of selected films. Prerequisite: Span 142 or equivalent. (HU)

Span 281. Spanish Cultural Program (1-6)
A program abroad. Formal instruction in Spanish grammar, conversation and culture during one or more months in Spain or Latin America on an approved program. (For LVAIC courses, see Span 191 and 291 below.) Prerequisite: Span 12. (HU)

Span 303. Don Quijote (3)
Reading and critical analysis. Prerequisite: Span 151. Lefkowitz. (HU)

Span 305. Spanish Literature of the Middle Ages (3)
Reading and discussion of outstanding works such as El Cid, El Libro de Buen Amor and La Celestina. Topics vary. Prerequisite: Span 151. Lefkowitz. (HU)

Span 308. Peninsular Literature Since 1939 (3)
Reading and discussion of representative contemporary Spanish poets, playwrights and novelists. Prerequisite: Span 151. Lefkowitz. (HU)

Span 320. Literature of the Spanish Caribbean (3)
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 (3)
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, and Silvina Ocampo. Prerequisite: Span 152. Prieto. (HU)

Span 322. The Short Novel in Contemporary Spanish American Literature (3)
Reading and discussion of representative works by Garcia Marquez, Onetti, Rulfo, Biyo Casares, and others. Prerequisite: Span 152. Prieto or O'Bryan. (HU)

Span 323. Literature and Revolution in Contemporary Cuba (3)
Study of works written after 1959 by dissident, non-dissident, and exiled authors (Desnoes, Noberto 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 (3)
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 "Boom" in Spanish American Literature (3)
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. O'Bryan. (HU)

Span 379. Internship (3)
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 391. Special Topics (3)
Study of an author, theme or period. Topics vary. May be repeated once for credit. Prerequisites: Span 151 or 152 and at least one 300-level course. Staff. (HU)

Study Abroad Programs
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 15 credits toward the major and 7 credits toward the minor.
Chinese
Chin 91. Chinese Language and Culture Abroad (1-6)
Intensive study of conversational Chinese in China; reading, development of writing skills and selected aspects of Chinese culture. (HU)

Chin 191. Intermediate Chinese Language and Culture Abroad (1-6)
Alternative to Chin 91 at the intermediate level. (HU)

Chin 291. Advanced Chinese Language and Culture Abroad (1-6)
Summer or semester study in China at advanced level. (HU)

French
Fren 191. French Language and Culture II Abroad (1-6)
Intensive practice in France of conversational French, rapid review of basic grammar, reading and analysis of moderately difficult texts, development of writing skills, supplemented by study of selected aspects of contemporary French civilization. Prerequisites: consent of chairperson and proficiency examination in France. (HU)

Fren 291. French Language and Culture III Abroad (1-6)
Intensive practice in France of spoken and written French, 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 French civilization. Prerequisites: consent of chairperson and proficiency examination in France. (HU)

German
Germ 191. German Language and Culture II Abroad (1-6)
Intensive practice in Germany of conversational German, rapid review of basic grammar, reading and analysis of moderately difficult texts, development of writing skills, supplemented by study of selected aspects of contemporary German civilization. Prerequisites: consent of chairperson and proficiency examination in Germany. (HU)

Germ 291. German Language and Culture III Abroad (1-6)
Intensive practice in Germany of spoken and written German, aimed at providing the student with extensive proficiency of expression and the ability to discriminate language 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 German civilization. Prerequisites: consent of chairperson and proficiency examination in Germany. (HU)

Hebrew

For courses in Israel including study of Hebrew, see Jewish Studies, page 37.

Japanese
Jpns 91. Japanese Language and Culture Abroad (1-6)
Intensive study of conversational Japanese in Japan; development of reading and writing skills; selected aspects of Japanese culture. (HU)

Jpns 191. Intermediate Japanese Language and Culture Abroad (1-6)
Alternative to Jpns 91 at the intermediate level. (HU)

Jpns 291. Advanced Japanese Language and Culture Abroad (1-6)
Summer or semester study in Japan at advanced level on selected topics. (HU)

Russian
Russ 91. Russian Language and Culture Abroad (1-6)
Intensive practice in Russia of conversational Russian, reading, development of writing skills and selected aspects of Russian culture. (HU)

Russ 191. Intermediate Russian Language and Culture Abroad (1-6)
Alternative to Russ 91 at a more advanced level. (HU)

Russ 291. Advanced Russian Language and Culture Abroad (1-6)
Summer or semester study in Russia at advanced level on selected topics. (HU)

Spanish
Span 191. Spanish Language and Culture II Abroad (1-6)
Intensive practice in Spain of conversational Spanish, 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 Spanish civilization. Prerequisites: consent of chairperson and proficiency examination in Spain. (HU)

Span 291. Spanish Language and Culture III Abroad (1-6)
Intensive practice in Spain of spoken and written Spanish 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 Spanish civilization. Prerequisites: consent of chairperson and proficiency examination in Spain. (HU)
Music

Associate Professor. Nadine Sine, Ph.D. (N.Y.U.), chairperson.
Assistant Professor. Casey Teske, D.M.A. (Catholic University).
Lecturer. Paul Chou, M.M. (Stony Brook).
Adjunct Professors. Nancy S. Bidlack, M.M. (Temple); James Koch, B.M. (NEC); Richard Metzger, M.M. (Marywood); Al Neumeyer, M.M. (Trenton); Lawrence Wright, M.M. (Juilliard).
Instrumental instructors. Chris DeSanto, clarinet; Frank DiBussolo, electric guitar; Robin Kani, flute; Martin Webster, French horn; Corinna Weidmer-Symer, oboe; Richard Metzger, guitar; Mike Melillo, jazz piano; Clint Miller, organ; James Koch, percussion; Helen Beedle, piano; HeeYoun Kim, piano; Pat O’Connell, piano; Debra Torok, piano; Mark Hulsebos, saxophone; Timothy Soberick, trombone; Lawrence Wright, trumpet; Grant Moore, tuba; Paul Chou, violin, viola; Nancy Bidlack, violoncello; Debra Field, voice; Vincent Metallo, voice; Carolyn Smith, voice.

Located in Lamberton Hall, the music department offers courses in music history, literature, theory, and composition, in addition to providing a wide range of performance experience in instrumental and vocal ensembles, and private instruction. Lamberton houses a listening library, practice rooms, an electronic studio, a computer assisted ear-training facility, and a large concert and rehearsal room.

A student graduating with the music major will have gained a strong foundation in the basics of music theory and substantial exposure to the style and repertoire of 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. Some students may find that 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.

Major program. Students majoring in music must take a minimum of 31 credit hours (excluding Mus 80), to include thirteen hours in musicianship and theory (Mus 11, 12, 13, 15, 82, 243, 245), nine in music history (any three from Music 233, 234, 235, 236), and three in performance courses (Mus 22-79). The student may choose the remaining seven credits from department offerings, including up to four additional performance or musicianship courses.

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 advisor, 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 1 to 6 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. A wide variety of instruments and voice lessons may be taken for one credit. They must be arranged through the department at set fees that are not included in tuition.

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 (e.g. only eight credits are applicable in the College of Arts and Science).

Music at Lehigh. The department sponsors Music at Lehigh, a professional concert series of about six performances a year open to students without charge.

Residencies. The Philadelphia Brass will be in residence during the 1995-96 year, working with students and performing a recital. Al DiMeola, electric guitarist, will have two three-day campus residencies.

Course Offerings

Please note that many upper level courses have no prerequisites beyond Mus 11 or 80 and are open to anyone with basic knowledge of musical terminology. Students may test out of Mus 11 by examination.

11. Basic Musicianship (1) fall
Rudiments of musical notation, beginning skills in sightsinging, eartraining, rhythm and keyboard. Students may test out of this course by examination. (HU)

12. Musicianship I (1) spring
Continuation of Mus 11. Prerequisite: Mus 11 or equivalent. (HU)

13. Musicianship II (1) fall, even
Continuation of Mus 12, with emphasis on counterpoint. Prerequisite: Mus 12. (HU)

15. Musicianship III (1) fall, odd
Continuation of Mus 12, with emphasis on chromatic harmony. Prerequisite: Mus 12. (HU)
21-79. 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: consent of the chairperson or audition by faculty member responsible for the course.

21. Marching Band (1) fall. (ND)
22. Wind Ensemble (1) spring (HU)
23. Concert Band (1) spring (HU)
24. Jazz Ensemble (1) fall-spring (HU)
25. Jazz Band (1) fall-spring (HU)
26. Wind Symphony (1) fall (HU)
31. University Choir (1) fall-spring (HU)
32. Choral Union (1) fall-spring (HU)
33. Overtones (1) fall-spring. Co-requisite: Mus 31 (HU)
41. String Ensemble (1) fall-spring (HU)
42. Mixed Ensemble (1) fall-spring (HU)
43. Brass Ensemble (1) fall-spring (HU)
44. Guitar Study (1) fall or spring
45. Percussion Ensemble (1) fall-spring (HU)
61. String Orchestra (1) fall-spring. (HU)
71. Private Piano Study (1) fall-spring (HU)
72. Private Vocal Study (1) fall-spring (HU)
73. Private String Study (1) fall-spring (HU)
74. Private Woodwind Study (1) fall-spring, (HU)
75. Private Brass Study (1) fall-spring (HU)
76. Private Percussion Study (1) fall-spring (HU)
77. Private Organ Study (1) fall-spring (HU)
78. Private Electric Guitar Study (1) fall-spring (HU)
79. Private Acoustic Guitar Study (1) fall-spring (HU)
80. Masterpieces of Music (3) fall or spring

82. Theory I: Harmony (3) spring
Exercises in writing in four-part chorale style. Must take in conjunction with or subsequent to Mus 12. Prerequisite: Mus 11 or equivalent. (HU)

90. Freshman Seminar (3)

100. History of Jazz (3)
The history of jazz from the beginning of the century until the present. Examination of the musical contributions of the leading figures in jazz—Joplin, Oliver, Armstrong, Morton, Henderson, Ellington, Basie, Parker, Gillespie, Davis, Coleman, Coltrane, etc. Emphasis on developing listening skills. Prerequisite: Mus 11 or 80 or equivalent. Salerni (HU)

110. 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 11 or 80 or equivalent. (HU)

120. 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 11, or 80, or equivalent. Sine. (HU)

231. Medieval and Renaissance Music (3) fall, odd
Development of musical style from early Christian chant to the sacred and secular forms of the late sixteenth century, viewed in cultural contexts. Prerequisite: Mus 11 or 80 or equivalent. Sine. (HU)

232. 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)

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)

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)

243. Theory II: Counterpoint (3) fall, even
Writing and analyzing pieces in Renaissance and Baroque contrapuntal styles. Must take Mus 13 concurrently. Prerequisite: Mus 82. Salerni. (HU)

245. Theory III: Form and Analysis (3) fall, odd
Analyzing and writing pieces in classical and romantic forms. Exercises in chromatic harmony. Must take Mus 15 concurrently. Prerequisite: Mus 82. Sametz. (HU)

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 chairperson. (HU)

253. Composition I: Electronic and Acoustic Techniques (3) fall
Writing for acoustic and electronic instruments based on twentieth-century models. Acoustic orchestration, simple recording techniques, analog and digital synthesis, effects processing. Use of the computer for score preparation and as a compositional tool. Prerequisite: Mus 82. Salerni. (HU)

254. Composition II (3) spring
Continuation of Mus 353. Prerequisite: 353. Salerni
Individually supervised work in history or composition, or continuation of projects begun in regular courses. May be repeated for credit. Prerequisite: consent of department chairperson. (HU)

300. Apprentice Teaching (1-3) (ND)

350. Senior Project (1-6) (HU)

Natural Science

Paul B. Myers

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 science 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 1 The Solar System (3)

EE 31, 32 Introduction to Environmental/Organismal Biology, and Laboratory
Psyc 1 Introduction to Psychology (4)

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)
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), chairperson, Andrew W. Mellon Distinguished Professor in the Humanities.

Associate professors. Gordon Bearn, Ph.D. (Yale); Robin S. Dillon, Ph.D. (Pittsburgh); Roslyn Weiss, Ph.D. (Columbia).

Assistant professor. Michael Mendelson, Ph.D. (San Diego).

The study of philosophy does several things for a student. It improves certain skills, such as the ability to analyze and evaluate arguments, to identify faulty reasoning, to reason well, and to read and understand a difficult and complex text. It provides an acquaintance with great works in philosophy which have influenced our culture. It teaches what our contemporaries are thinking about whether moral standards are objective, or when claims to know can be justified, or how the mind is related to the brain. It identifies important philosophical issues in medicine, business, religion, science and the law. Students of philosophy study the foundations of their views about themselves and their world.

Students who major in philosophy are well prepared for graduate study; but the skills fostered by the major program are of value to a variety of careers or post-baccalaureate pursuits. Some of our majors have gone into banking, communications, insurance, marketing and publishing, immediately after graduation. Others, after graduate or professional school, go into academic philosophy, law, medicine, urban planning, and corporate management. There are also courses of general interest to students from all four colleges.

The philosophy faculty emphasizes interaction with students. Students often participate with faculty members in a "reading party"—a retreat where students and faculty read and discuss ideas together for a few days. They can attend
lectures by distinguished philosophers who visit the campus and participate in discussions with faculty and students. They can join the Philosophy Club, which brings students and faculty together in small group activity.

Department honors are awarded on the basis of a thesis or a disputation (a public defense of a philosophical thesis) supervised by one or more members of the department, and the attainment of a cumulative average for all courses in philosophy of 3.25 or better at the time of graduation.

The Minor Program
The minor in philosophy consists of six courses. The courses will include Phil. 131 and at least one course at the 200-level. Minor programs may be either of a general character or organized around a special theme such as the philosophy of science, logic, ethics, the history of philosophy, or social philosophy.

The Major Program
The major in philosophy consists of thirty-three credit hours of course work. The specific courses to be taken are decided jointly by the student and the departmental adviser. All major programs include the following:

- Phil 114 Foundations of Logic (3)
- Phil 131 Ancient Philosophy (3)
- Phil 135 Modern Philosophy (3)
- Phil 291 Seminar (3)

Plus, one of the following:

- Phil 105 Ethics (3)
- Phil 205 Contemporary Ethics (3)

Plus one of the following:

- Phil 128 Philosophy of Science (3)
- Phil 220 Knowledge and Justification (3)
- Phil 228 Topics in the Philosophy of Science (3)

All major programs must include in the 33 total credit hours at least three courses at the 200-level or above. At the discretion of the department, a major may be required to take and pass English 171, Practical Writing.

Undergraduate Courses

10. Introduction to Philosophy (3)
Basic philosophical questions, perennial and contemporary, such as the objectivity of morals, the justification of government, the place of mind and feeling in the world of matter and energy, the nature of knowledge and truth, and the reality of God.

105. Ethics (3)
Examination of right and wrong, good and bad, from classic sources such as Plato, Aristotle, Hume, Kant, Mill and Nietzsche.

113. Practical Logic (3)

The role of logic in problem solving and decision-making processes. Comparison of deductive and inductive reasoning and justification. Practice in analysis, criticism, evaluation and construction of arguments. Emphasis on material drawn from real-life contexts.

114. Fundamentals of Logic (3)
A computer-based, self-paced introduction to symbolic logic, including predicate logic and proofs.

116. Medical Ethics (3)
Contemporary moral problems encountered in the practice of medicine examined in the light of ethical theories of the nature and foundation of rights and moral obligations. Abortion, euthanasia, genetic engineering, the nature of informed consent, the distribution of health care, etc.

122. Philosophy of Law (3)
Analysis of the conceptual foundations of our legal system. Special attention is 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.

123. Aesthetics (3)
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. Bearn

126. Feminism and Philosophy
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, sex roles and gender differences, sexism, femininity, sexuality, reproduction, mothering. Dillon

128. Philosophy of Science (3)
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?

131. (Clss 131) Ancient Philosophy (3)
Historical study of philosophy in the classical world. The origins of the Western tradition in philosophy and science with the Presocratics; Socrates, Plato (including Republic) and Aristotle (including parts of Nicomachean Ethics). Weiss

133. Medieval Philosophy (3)
Historical study of philosophy from the Roman Empire to the Renaissance. Attention to Islamic, Jewish, and Christian traditions and their interaction with the scientific and cultural life of the period. Mendelson

135. Modern Philosophy (3)
Philosophers from the Renaissance through the end of the 19th century: Descartes, Locke, Hume, Rousseau, Kant and Hegel. Mendelson

139. Contemporary Philosophy (3)
Philosophical thought from the late-19th century to the present; pragmatism, linguistic analysis, existentialism, and Marxism. Truth and knowledge, values and moral judgment, meaning, the place of the individual in the physical world and society, and the impact of scientific method upon all of these.

181. (Rel 181) Reason and Religious Experience (4)
A critical look at some of the 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.

205. Contemporary Ethics (3)
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 chairperson. Dillon

220. Knowledge and Justification (3)
Recent work in epistemology. Questions addressed include: If you can'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? Bearn

224. (Rel 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. Prerequisite: Phil 124 or consent of the department chairperson.

228. Topics in the Philosophy of Science (3)
Themes in the natural, life and social sciences. May be repeated for credit as topic varies. Prerequisite: Phil 128 or consent of the department chairperson.

237. (Rel 237) Kierkegaard and Nietzsche (3)
Two maverick thinkers of the 19th century, concerned with religious faith, values, and the meaning of human existence.

239. Heidegger and Wittgenstein
Two influential philosophers of the 20th Century. Heidegger is among the founders of Existentialism and Wittgenstein of Ordinary Language Philosophy. They are both concerned to understand the place of humans on the earth as more intimate than that of an intellect in space. The Late Romantic attempt to recover the ordinary. Bearn

250. The Minds of Men and Robots (3)

251. Action, Free Will, and Fate (3)
Are we free to act as we choose? Are we free to choose? The concept of action: intentions and actions, reasons and causes, and whether there can be deterministic explanations of actions. Prerequisite: one previous course in philosophy (except 113, 221).

271. Readings in Philosophy (1-3)
A course in readings designed primarily for the undergraduate philosophy majors and minors and graduate students in other disciplines. Prerequisite: consent of the department chairperson.

272. Readings in Philosophy (1-3)
A course of readings designed primarily for undergraduate philosophy majors and minors and graduate students in other disciplines. Prerequisite: consent of the department chairperson.

291. Seminar (3)
Examination of selected topics for philosophy majors and minors and other advanced students. May be repeated for credit.

Physics

Professors. Arnold H. Kritz, Ph.D. (Yale), chairperson;
Garold J. Borse, Ph.D. (Virginia), associate chairperson;
Gary G. DeLeo, Ph.D. (Connecticut); 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. Huemelens, Ph.D. (Colorado); Alvin S. Kanofsky, Ph.D. (Pennsylvania); Yong W. Kim, Ph.D. (Michigan);
Selden H. Radin, Ph.D. (Yale); Michael Stavola, Ph.D. (Rochester); Jean Toulouse, Ph.D. (Columbia).

Associate professors. Brent W. Benson, Ph.D. (Pens State);
Daniel C. Hong, Ph.D. (Boston Univ.); Jerome C. Lieini,
Ph.D. (M.I.T.); Michelle S. Malecuit, 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).

Lehigh offers four undergraduate degrees in physics: the Bachelor of Science in Physics and the Bachelor of Arts in Physics in the College of Arts and Sciences, and the Bachelor of Engineering Physics and the five year program for the Bachelor of Science in Electrical Engineering and Engineering Physics in the College of Engineering and Applied Science.

(The B.S. in E.E.E.P. is described on p. 218).

The two bachelor of science curricula require somewhat more physics and mathematics than the bachelor of arts major, while the latter requires more courses in the humanities and social sciences. By proper choice of electives, any of these
programs 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 knowledge of physics is needed or useful, but is not the main subject, such as science writing, secondary school teaching, patent law, or medicine.

A comparison of the three curricula in terms of credit hours in various broad categories is given below.

<table>
<thead>
<tr>
<th>College of Arts and Science</th>
<th>Engineering College</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman English</td>
<td>B.S. 6  B.A. 6  B.S.E.P. 6</td>
</tr>
<tr>
<td>Distribution Courses*</td>
<td>20 20 18</td>
</tr>
<tr>
<td>Required preliminary and major courses</td>
<td>66 61 67</td>
</tr>
<tr>
<td>Approved Electives</td>
<td>14 11 14</td>
</tr>
<tr>
<td>Electives</td>
<td>18 23 20</td>
</tr>
<tr>
<td>Total</td>
<td>124 121 125</td>
</tr>
</tbody>
</table>

*Not including mathematics or science

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. For example, by combining various electrical engineering courses with physics courses in electronics and solid-state physics, a strong applied background can be developed for employment in solid-state electronics. If the student chooses applied mathematics courses and computer courses to supplement the physics courses, a strong preparation can be achieved for employment in the many areas that use numerical methods in analysis and development.

Many other specialties may be developed by the student by appropriate use of electives so that the bachelor-degree student can offer an employer the advantages of a broad and fundamental science background combined with a significant concentration in a particular area of science, engineering, or applied mathematics.

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, material 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.

The recommended sequences of courses for the three degrees are:


Freshman Year
FALL Semester
Freshmen Freshmen Freshmen
Engl 1 (3) Engl 1 (3) Engl 1 (3)
Phy 11 (Lec) (4) Phy 11 (Lec) (4) Phy 11 (Lec) (4)
Phy 12 (Lab) (1) Phy 12 (Lab) (1) Phy 12 (Lab) (1)
Math 21 (4) Math 21 (4) Math 21 (4)
Col. Seminar (3) Col. Seminar (3) HSS (3)
A+S 1 (1) A+S 1 (1) Engr 2 (1)

SPRING Semester
One of One of One of
Engl 2, 4, 6, 8, or 10 (3) Engl 2, 4, 6, 8, or 10 (3) Engl 2, 4, 6, 8, or 10 (3)
Chm 21 (Lec) (4) Chm 21 (Lec) (4) Chm 21 (Lec) (4)
Chm 22 (Lab) (1) Chm 22 (Lab) (1) Chm 22 (Lab) (1)
Math 22 (4) Math 22 (4) Math 22 (4)
Dist. Req. (3) *Engr 1 (3) Engr 1 (3)

Sophomore Year
FALL Semester
Phy 21 (Lec) (4) Phy 21 (Lec) (4) Phy 21 (Lec) (4)
Phy 22 (Lab) (1) Phy 22 (Lab) (1) Phy 22 (Lab) (1)
Math 23 (4) Math 23 (4) Math 23 (4)
Dist. Req. (6) Dist. Req. (6) Eco 11 or 12 (3)

SPRING Semester
Phy 31 (3) Phy 31 (3) Phy 31 (3)
Phy 190 (3) Phy 190 (3) Phy 190 (3)
Math 205 (3) Math 205 (3) Math 205 (3)
<table>
<thead>
<tr>
<th></th>
<th>Junior Year</th>
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<tbody>
<tr>
<td><strong>FALL Semester</strong></td>
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<td></td>
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<tr>
<td>Phy 212</td>
<td>(3)</td>
<td>Phy 212</td>
<td>(3)</td>
</tr>
<tr>
<td>Phy 215</td>
<td>(4)</td>
<td>Phy 215</td>
<td>(4)</td>
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<tr>
<td>Phy 260**</td>
<td>(2-3)</td>
<td>Phy 260</td>
<td>(2)</td>
</tr>
<tr>
<td>Elective</td>
<td>(2-3)</td>
<td>Phy 260**</td>
<td>(2)</td>
</tr>
<tr>
<td>Math 322</td>
<td>(3)</td>
<td>Math 322</td>
<td>(3)</td>
</tr>
<tr>
<td>Dist. Req.</td>
<td>(3)</td>
<td>Dist. Req.</td>
<td>(3)</td>
</tr>
<tr>
<td>Electives</td>
<td>(4)</td>
<td>Electives</td>
<td>(4)</td>
</tr>
<tr>
<td></td>
<td>(16-16)</td>
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<td>(16)</td>
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<tr>
<td><strong>SPRING Semester</strong></td>
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<tr>
<td>Phy 213</td>
<td>(3)</td>
<td>Phy 213</td>
<td>(3)</td>
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<tr>
<td>Phy 261**</td>
<td>(3-2)</td>
<td>Phy 261</td>
<td>(2)</td>
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<tr>
<td>Phy 264</td>
<td>(3)</td>
<td>Phy 264</td>
<td>(3)</td>
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<tr>
<td>Phy 362</td>
<td>(3)</td>
<td>Phy 362</td>
<td>(3)</td>
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<tr>
<td>Elective</td>
<td>(3)</td>
<td>Elective</td>
<td>(4)</td>
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<tr>
<td>HSS</td>
<td>(3)</td>
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<td></td>
<td>(15-14)</td>
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<td>(14)</td>
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<tr>
<td><strong>Senior Year</strong></td>
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<tr>
<td><strong>FALL Semester</strong></td>
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<tr>
<td>Phy 340</td>
<td>(3)</td>
<td>Phy 340</td>
<td>(3)</td>
</tr>
<tr>
<td>Electives</td>
<td>(6)</td>
<td>Appr. Elec.</td>
<td>(8)</td>
</tr>
<tr>
<td>Electives</td>
<td>(6)</td>
<td>Electives</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>(14)</td>
<td></td>
<td>(15)</td>
</tr>
<tr>
<td><strong>SPRING Semester</strong></td>
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<td></td>
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<tr>
<td>Phy 171</td>
<td>(1)</td>
<td>Phy 171</td>
<td>(1)</td>
</tr>
<tr>
<td>Electives</td>
<td>(8)</td>
<td>Electives</td>
<td>(10)</td>
</tr>
<tr>
<td>HSS</td>
<td>(3)</td>
<td>Electives</td>
<td>(6)</td>
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<td>(121)</td>
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<td></td>
<td>(125)</td>
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</tbody>
</table>

*or an equivalent course in scientific computing

**only one of the two lab courses (PH 260/1) is required for the B.A.

The electives include at least fourteen credit hours for Bachelor of Science degrees and eleven credit hours for the Bachelor of Arts degree of approved technical electives. Included in this group must be two of the following courses: Phys 363, 369, (352 or 355), and (348 or 365). Students planning graduate work in physics are advised to include Phys 273 and 369 among their electives. Up to 6 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.

**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/masters programs.** Five-year programs that lead to successive bachelor and masters degrees are available. These programs satisfy all of the requirements of one of the three bachelor's degrees in Physics (B.A., 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 42. 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

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 Phys 11. Prerequisites: three credit hours of advanced placement, anticipatory exam, or transfer credit for the mechanics part of Phys 11, and consent of the chairperson of the department.

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 41, previously or concurrently. DeLeo or Borse. (NS)

12. Introductory Physics Laboratory I (1)
A laboratory course taken concurrently with Phys 11. Experiments in mechanics, heat, and DC electrical circuits. One three-hour laboratory period per week. Prerequisite: Phys 11, preferably concurrently. Ou-Yang

13. General Physics (3)
A continuation of Phys 11, primarily for students in the College of Arts and Science and premedical students. Electrostatics, electromagnetism, light, atomic physics, nuclear physics and radioactivity. Prerequisites: Phys 11 and Math 21, 31 or 41. Radin. (NS)

14. General Physics Laboratory (1)
A laboratory course to be taken concurrently with Phys 13. Prerequisite: Phys 12; Phys 13, preferably concurrently. Folk

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 Phys 21. Prerequisites: three credit hours of advanced placement, anticipatory exam, or transfer credit for the electricity and magnetism part of Phys 21, and consent of the chairperson of the department. (NS)

21. Introductory Physics II (4)
A continuation of Phys 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 44, previously or concurrently. Folk or Shaffer. (NS)

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

31. Introduction to Quantum Mechanics (3)
Experimental basis and historical development of quantum mechanics; the Schrödinger 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. Benson, Stavola. (NS)

42. Concepts in Physics (3)
The principal concepts and discoveries of physics are presented in a concise manner. The purpose of the course is to provide students majoring in subjects other than science and engineering with sufficient background to enable them to appreciate physics and its impact on modern society. The laboratory serves to demonstrate the concepts covered in class and to provide some exposure to modern measurement devices and computers. High school physics is not assumed. Two recitations and one laboratory per week. No prerequisite. DeLeo. (NS)

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: Phys. 21 and 22 or their equivalent or consent of chairperson. Kim. (NS)

171. Physics Proseminar (1)
Discussion of current problems in physics. Intended for seniors majoring in the field. (NS)

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. Smith. (NS)
For Advanced Undergraduates And Graduate Students

212.  Electricity and Magnetism I (3)
Electrostatics, magnetostatics, and electromagnetic induction.
Prerequisites: Phys 21 or 13; Math 205, previously or concurrently. Huennekens.  (NS)

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: Phys 212. Licini. (NS)

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: Phys 21 or Phys 13 and Math 205, previously or concurrently. Kanofsky. (NS)

260.  Laboratory Techniques (2)
Laboratory practice, including machine shop, vacuum systems, electronic instrumentation, computers and integrated circuits, high-voltage measurements, counting and statistics. Prerequisites: Phys 21 and 22, or Phys 13 and 14. Kanofsky. (NS)

261.  Optics, Spectroscopy, and Quantum Physics Laboratory (2)
Experiments in geometrical optics, interference and diffraction, spectroscopy, lasers, and quantum phenomena. Prerequisites: Phys 21 and 22, or Phys 13 and 14. Malcuit. (NS)

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: Phys 31 and Math 205. Kanofsky. (NS)

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)

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)

282.  Basic Physics II (3)
Continuation of Phys 281. (NS)

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 chairperson. May be repeated for credit. (NS)

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 44, previously or concurrently, and Phys 21. (NS)

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: Phys 13 or 21, and Math 23, 32 or 44. Stavola. (NS)

342.  (Astr 342) Relativity and Cosmology (3)
Special and general relativity. Schwarzschild and Kerr black holes. Super massive stars. Relativistic theories of the origin and evolution of the universe. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21. (NS)

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: Phys 21, Math 205, and senior standing or consent of the chairman of the department. Kritz (NS)

352.  Modern Optics (3)
Paraxial optics, wave and vectorial theory of light, coherence and interference, diffraction, crystal optics, and lasers. Prerequisites: Math 205, and Phys 212 or ECE 202. Radin. (NS)

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: Phys 31; Phys 213 or ECE 203, previously or concurrently. Malcuit. (NS)

362.  Atomic and Molecular Structure (3)
Review of quantum mechanical treatment of one-electron atoms, electron spin and fine structure, multi-electron atoms,
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).** Optical and electronic properties of defects in semiconductors and insulators, electron paramagnetic resonance, ultrasonic attenuation, Raman spectroscopy, luminescence spectroscopy. Properties of thin films, physics of semiconductor devices. Colloidal suspensions and complex fluids.

**Solid-state physics (experimental).** Electronic properties of defects in semiconductors and insulators, electronic structures, electron-lattice interactions, energy band calculations.


**Plasma Physics (Theoretical).** Studies of heating, current drive, transport, 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.

**Plasma spectroscopy.** Collisional and collisionless phenomena of very dense plasmas. Laser-produced plasmas.

**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.

**Elementary particles (theoretical).** Properties of leptons and vector bosons, weak and electromagnetic interactions. Quark-Glauber calculations of elastic and inelastic scattering.

**Non-linear optics.** Theoretical and experimental work in lasers and non-linear optics.

**Van de Graaff studies.** Experiments to study nuclear reactions, channeling, new instrumentation techniques, Rutherford back-scattering using the Lehigh van de Graaff accelerator.

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 may make up deficiencies in addition to taking the specified work for the degree sought.

Doctoral candidates may be required by their thesis committee to demonstrate a reading knowledge of one language, usually chosen from French, German or Russian.

Certain advanced courses in other fields, notably mechanics, metallurgy and materials engineering, electrical engineering, and chemistry, may be included in a graduate program. Further details regarding the special requirements for degrees in physics may be obtained on application to the department chairman.

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. The 1985-86 renovation and addition to the Physics Building 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 pulsed 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

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

420. Mechanics (3)
Includes the variational methods of classical mechanics, methods of Hamilton and Lagrange, canonical transformations, Hamilton-Jacobi Theory. Streater

421. Electricity & Magnetism I (3)
Electrostatics, magnetostatics, Maxwell's equations, dynamics of charged particles, multipole fields. Kim

422. Electricity & Magnetism II (3)
Electrodynamics, electromagnetic radiation, physical optics, electrodynamics in anisotropic media. Special theory of relativity. Prerequisite: Phys 421. Licini

424. Quantum Mechanics II (3)
General principles of quantum theory; approximation methods; spectra; symmetry laws; theory of scattering. Prerequisite: Phys 369 or equivalent. Toulouse

425. Quantum Mechanics III (3)

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. Folk

429. Methods of Mathematical Physics II (3)
Continuation of Phys 428 to include the use of integral equations, Green's functions, group theory, and more on numerical methods. Prerequisite: Phys 428. Folk

431. Theory of Solids (3)

442. Statistical Mechanics (3)
General principles of statistical mechanics with application to thermodynamics and the equilibrium properties of matter. Prerequisite: Phys 340 and 369. Kim

443. Nonequilibrium Statistical Mechanics (3)
A continuation of Phys 442. Applications of kinetic theory and statistical mechanics to nonequilibrium processes; non-equilibrium thermodynamics. Prerequisite: Phys 442. Hong

446. 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: Phys 424 or consent of the department. Huenekeens

455. 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-doubling routes to chaos and strange attractors, fractal geometry and devil's staircase. Examples of both dissipative and conservative systems will be drawn from fluid flows,
plasmas, nonlinear optics, mechanics and waves in disordered media. Prerequisites: graduate standing in science or engineering, or consent of the chairman of the department. Kim

462. Theories of Elementary Particle Interactions (3)
Relativistic quantum theory with applications to the strong, electromagnetic, and weak interactions of elementary particles. Prerequisite: Phys 425. Shaffer

465. Nuclear and Elementary Particle Physics (3)
Nuclear structure and phenomena; interactions among elementary particles and methods of studying them. Kanofsky

467. Nuclear Theory (3)
Theory of low-energy nuclear phenomena within the framework of nonrelativistic quantum mechanics. Borse

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. Smith

472. Special Topics in Physics (1-3)
Selected topics not sufficiently covered in the more general courses. May be repeated for credit.

474. Seminar in Modern Physics (3)
Discussion of important advances in experimental physics. May be repeated for credit when a different topic is offered.

475. Seminar in Modern Physics (3)
Discussion of important advances in theoretical physics. May be repeated for credit when a different topic is offered.

491. Research (3)
Research problems in experimental or theoretical physics.

492. Research (3)
Continuation of Phys 491. May be repeated for credit.

**Psychology**

**Professors** Mark H. Bickhard, Ph.D. (Chicago), Henry R. Luce Professor in Cognitive Robotics and the Philosophy of Knowledge; Martin L. Richter, Ph.D. (Indiana); George K. Shortess, (Brown), Professor Emeritus.

**Associate Professors** Susan Barrett, Ph.D. (Brown); Diane T. Hyland, Ph.D. (Syracuse), chairperson; Barbara C. Malt, Ph.D. (Stanford); William Newman, Ph.D. (Stanford); S. Lloyd Williams, Ph.D. (Stanford).

**Assistant Professors** James D. Jackson, Ph.D. (Kansas); Padraig O’Seaghdha, Ph.D. (Toronto); Elissa D. Wurf, Ph.D. (Michigan).

**Adjunct Professors** Ian Birky, Ph.D. (Oklahoma State); Roy C. Herrenkohl, Ph.D. (N.Y.U.); Edwin J. Kay, Ph.D. (Lehigh); Judith N. Lasker, Ph.D. (Harvard); John G. Nyby, Ph.D. (Texas, Austin); Robert E. Rosenwein, Ph.D. (Michigan); Edward S. Shapiro, Ph.D. (Pittsburgh); Neal G. Simon, Ph.D. (Rutgers); Arnold R. Spokane, Ph.D. (Ohio State).

**Major Program in Psychology**
The bachelor of arts in psychology is a social science major requiring a minimum of 35 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**

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<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>Psyc 1</td>
<td>Introduction to Psychology</td>
<td>4</td>
</tr>
<tr>
<td>Psyc 110</td>
<td>Experimental Design and Statistical Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Psyc 210</td>
<td>Experimental Psychology</td>
<td>3</td>
</tr>
</tbody>
</table>

**Plus the following one from each of the four categories**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>Psyc 107</td>
<td>Child Development</td>
</tr>
<tr>
<td>Psyc 109</td>
<td>Adulthood and Aging</td>
</tr>
<tr>
<td>Psyc 21</td>
<td>Social Psychology</td>
</tr>
<tr>
<td>Psyc 153</td>
<td>Personality</td>
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<tr>
<td>Psyc 117</td>
<td>Cognitive Psychology</td>
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<tr>
<td>Psyc 171</td>
<td>Learning</td>
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<tr>
<td>Psyc 176</td>
<td>Mind and Brain</td>
</tr>
<tr>
<td>Psyc 177</td>
<td>Introduction to Behavioral Neuroscience</td>
</tr>
</tbody>
</table>

and at least four 300-level Psychology courses, excluding Psyc 300 (Apprentice teaching), Psyc 393 (Research), and Psyc 395, 396 (Thesis).

**Additional Required Courses.** All students must also fulfill College of Arts and Science distribution requirements, and successfully complete at least 121 credit hours for graduation.

**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:

<table>
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<tr>
<th>Course</th>
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<tbody>
<tr>
<td>Psyc 161</td>
<td>Supervised Research</td>
</tr>
<tr>
<td>Psyc 393</td>
<td>Independent Research</td>
</tr>
<tr>
<td>Psyc 395</td>
<td>Thesis</td>
</tr>
<tr>
<td>Psyc 421, 422</td>
<td>Analysis and Design of Experiments</td>
</tr>
</tbody>
</table>
junior year with an over-all GPA of 3.0; and have completed the Honors Program in Psychology. Students interested in applying psychology to fields such as law, marketing, social work, or education should consult with the appropriate pre-professional advisers to determine specific requirements.

Students interested in applying psychology to fields such as law, marketing, social work, or education should consult with the appropriate pre-professional advisers to determine specific requirements.

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 over-all 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 fifteen credit hours in psychology beyond the introductory course (Psych 1, 21). 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

1. Introduction to Psychology (4)
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. Three hour lecture and one hour recitation per week. (SS)

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. Not offered to students who have had Soc Psych 7. (SS)

31. Normal and Altered States of Consciousness (3)
Normal and altered states of consciousness are defined. These include waking, sleep, meditation, madness, and drug states. Newman. (SS)

65. Art 65 Perception and the Visual Arts (3)
Perceptual and cognitive theories and principles as related to visual fine arts and aesthetic experience. (HU)

77. Drugs and Behavior (3)

81. Psychology and Law (3) fall
Contributions of psychological research to understanding the legal system. Eyewitness testimony; jury selection and decision making, sentencing; the rights of mental patients; psychologists as expert witnesses. Barrett. (SS)

107. Child Development (3)
Survey of theories and research concerning perceptual, cognitive, social, and personality development through infancy and childhood. Prerequisite: Psych 1. Barrett. (SS)

108. Adolescence Development (3)
Descriptions and explanations of cognitive, personality, and physical development during the adolescent and early adult years. The stresses of adolescence and the difficulties that individuals encounter in their initial attempts to function as adults. Prerequisite: Psych 1. (SS)
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. Hyland. (SS)

110. Experimental Design and Statistical Analysis (3)
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. Richter. (ND)

117. Cognitive Psychology (3)
Information processing by human beings: attention, memory, language, and thought processes. Prerequisite: Psyc 1 or CogS 7. Malt, O'Seaghdha. (SS)

121. Encountering Self and Others (3)
An experientially oriented course to facilitate personal growth and develop a fuller awareness of personal functioning and interpersonal perception and communication. Pass-fail grading. Prerequisite: consent of the department chairperson. Newman. (SS)

125. (SSP 125) 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)

135. (SSP 135, Jour 135) Human Communications (3)
Processes and functions of human communication in relationships and groups. Rosenwein. (SS)

140. (CogS 140, MFL 140) Introduction to Linguistics (3)
Relationship between language and mind; formal properties of language; language and society; how languages change over time. (SS)

153. (SSP 153) Personality (3)
Review and critique of theories of personality and their associated systems of psychotherapy. Prerequisite: Psyc 1, Psyc 21 or SSP 21. Williams, Wurf. (SS)

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 also discusses the research and practice. Prerequisite Psych 1. Williams. (SS)

160. Independent Study (1-3)
Readings on topics selected in consultation with a staff member. Prerequisite: Psyc 1 and consent of the department chairperson. May be repeated for credit. Fulfills natural science or social science distribution requirements for students in the College of Arts and Science by petition only. (SS)

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. Prerequisite: Psyc 1 and consent of sponsor. (SS)

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. Prerequisite: Psyc 1 plus two additional psychology courses and consent of instructor. (SS)

165. (Art 165) Perception and the Visual Arts Studio (3)
Projects exploring the relationships between human visual perception and the visual arts. Visual thinking and creative problem solving. Prerequisite: Psyc 65 or Art 65 or consent of instructor. (IH)

171. Learning Processes and Applications (3)
Experimental data on animal and human conditioning and learning. Applications to mental health, mental retardation, education. Prerequisite: Psyc 1. (SS)

176. Mind and Brain (3)
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. (NS)

177. (BEB 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: Psyc 1 or Introductory Biology. Nyby, Simon. (NS)

201. 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. Prerequisite: Psyc 1. (SS)

210. Experimental Psychology (4)
Data collection and research methods in various areas of psychology. Laboratory exercises, report writing and an independent research project. Prerequisites: Psyc 1 and 110 and consent of department chairperson. (ND)

277. (BEB 277) Behavioral Neuroscience Laboratory (2)
Nervous system structure; preparation of nervous tissues for microscopic examination; experiments on behavioral assays of nervous system function. Prerequisite: Psyc 177. Cundall, Schneider. (NS)

305. Abnormal Psychology (3)
Examines research and theory on the patterns, causes, and
treatment of various forms of abnormal behavior.
Prerequisite: Psy 1 or consent of the department
chairperson. Williams. (SS)

307. Seminar in Cognition (3)
Selected research and theory in cognitive psychology and
cognitive science. Attention; knowledge; representation;
memory; mental imagery; decision making; reasoning; nature
of expertise; language processes; reading; effects of brain
damage. Prerequisite: Psy 117 or CogS 7 or consent of
instructor. O'Seaghdha, Malt. (SS)

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.
(S) (SS)

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.
Rosenwein. (SS)

314. (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. (SS)

315. History of Modern Psychology (3)
Origin and development of major theories within perception,
cognition, biological, clinical, personality, developmental,
learning. Nineteenth and twentieth century thought to provide
an overview of psychology as a discipline. Prerequisite: Psy
1. (SS)

318. (WS 318) Seminar in Gender and Psychology (3)
Gender as shaped by psychological and social psychological
processes. Socialization, communication and power, gender
stereotypes, methodological issues in sex differences
research. Prerequisite: Psy 210 or permission of instructor.
Hyland, Wurf. (SS)

320. (Educ 320) Psychology of Language (3)
Study of the experimental and observational literature on
psychological processes involved in the production,
comprehension, and use of language by adults. Malt. (SS)

322. (SSP 323) 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. (SS)

329. Seminar in Advanced Social Research Methods (3)
Spring
Issues related to participant selection and recruitment,
research design, measurement, and data collection. Readings,
apprenticeship in ongoing faculty social and behavioral
research projects, and an independent research proposal.
Prerequisite: Psy 210 or SR 111 and permission of
instructor. (ND)

331. Humanistic Psychology (3)
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. Prerequisite: Psy 1. Newman. (SS)

333. (SSP 333, Govt 333) Social Psychology of Politics
(3)
Political behavior viewed from a psychological and social
psychological perspective. Rosenwein. (SS)

335. (BEB 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: BEB 31 or EES 31 or MBio 101. Itzkowitz.
(NS)

337. (BEB 337) Behavioral Ecology (3)
Social systems of vertebrate and invertebrate groups.
Emphasis on ecological and evolutionary factors that
influence social behavior. Prerequisite: Consent of
department chairperson. Not open to students who have taken
Biol 498. Prerequisite: BEB 31 or EES 31 or MBio 101.
Itzkowitz. (NS)

351. Cognitive Development in Childhood (3)
Piaget and alternative theoretical approaches. Research on
development of memory, comprehension, communication,
classification, and social cognition. Prerequisite: Psy 107,
117, or CogS 101. Barrett. (SS)

352. (SpEd 331) Emotional and Behavioral Disorders
(3)
Definition, classification, etiology, treatment, and historical
perspective of individuals with emotional and behavioral
disorders. (NS)

354. Personality Assessment (3)
Methods of describing and measuring personality.
Observational techniques, interviews, self-report inventories,
intelligence tests, and projective tests. Prerequisite: Psy 1.
Williams, Wurf. (NS)

356. (SSP 356) Seminar in Personality Psychology (3)
Topics in personality psychology: the self, personality
consistency, motivation, psychological adjustment.
Prerequisite: Psy 153 or consent of instructor. Williams,
Wurf. (SS)
358. **Seminar in Infant Development (3)**
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. Prerequisite: Psych 107 and consent of department chairperson. Barrett. (SS)

361. **(SSP 361) Personality and Social Development in Adulthood (3)**
Theories and current research. Prerequisite: Psyc 109 or consent of department chairperson. Hyland. (SS)

363. **Personality and Social Development in Childhood (3)**
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: Psyc 107 or 108 or 109 or consent of instructor. (SS)

365. **Cross-cultural Perspectives on Aging (3)**
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: Psyc 109. Jackson. (SS)

371. **Theories of Learning (3)**
Critical evaluation of classical and contemporary theories of learning including review of relevant experimental research. Prerequisite: Psyc 171. (ND)

373. **(BEB 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: Psyc 65 or 176 or 177. (SS)

374. **Sensation and Perception Laboratory (1)**
Laboratory exercise applying quantitative methods to the study of sensory processes. Prerequisites: Psyc 210; Psyc 373, previously or concurrently. (ND)

375. **(Biol 375) Neuroanatomy of Behavior (3)**
Neuroanatomy and neurophysiology of animal and human behavior. Feeding, thirst, sleep, emotions, learning, and psychopathology. Prerequisite: Psyc 177 or Biol 220 or 223 or 335. Simon, Nyby. (ND)

377. **Seminar in Physiological Psychology (3)**
Selected topics examining the physiological and/or genetic determinants of human and animal behavior. Prerequisite: Psyc 177 and consent of instructor. Nyby, Simon. (ND)

382. **(BEB 382) Endocrinology of Behavior (3)**
Hormonal effects upon animal and human behavior. Emphasis on neuroendocrinology of steroid hormone involvement in reproductive behaviors. Prerequisite: Psyc 177 or Biol 220 or 223 or 335. Nyby, Schneider, Simon (NS)

391. **(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 112 or consent of department chairperson. Herrenkohl. (ND)

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. Prerequisite: Psyc 210 or 161 and consent of sponsor. (ND)

395. **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 chairperson. (ND)

396. **Thesis (3)**
Execution of project designed in Psych 395. Final report and oral presentation. Prerequisite: Psyc 395 and consent of the department chairperson. (ND)
For Graduate Students
The department of psychology offers the doctor of philosophy degree with specializations in biopsychology, cognition, development, and personality. The program emphasizes a commitment to research and the fostering of teaching skills. Students are trained primarily for positions at universities and those involving basic or applied research.

Requirements for a doctoral degree at Lehigh. The Graduate School requires 72 credit hours for a doctoral degree for those entering with a bachelor of arts or bachelor of science degree; 42 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 data-based) 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 must complete an approved course in at least 3 of the 4 specialization areas in the department.

Psyc 421 and 422, Analysis and Design of Experiments. These courses represent a two-semester sequence of theoretical and applied statistics and research methodology.

Psyc 400+, Graduate Seminars. Students must take at least four graduate seminars approved by the faculty.

Psyc 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.

General Examination
This is required for all doctoral candidates and must be passed at least seven months prior to the awarding of the degree. The student may opt for a major/minor or a major only exam; subareas to be covered on the exam are selected by the student in consultation with the student's general exam committee.

Evaluation
Graduate students are evaluated on their performance in course work, research, teaching, assistantship assignments, and the general examination. The faculty provides each student with a written evaluation of progress in the graduate program annually.

Financial Support
Support is available in the form of teaching and research assistantships, fellowships, and scholarships. There are special fellowships for minority students. While a good undergraduate background in psychology is desirable, promising students with majors other than psychology are encouraged to apply.

How to apply
Applications for admission and financial aid may be obtained from the Department of Psychology. Completed application forms plus transcripts, letters of recommendation, and a report of scores on the Graduate Record Examination and advanced tests in psychology should be returned to the office of Graduate Admission not later than February 1 of the year of admission. New students are normally accepted for entrance into the program only for the fall semester.

Graduate-Level Courses
402. (SchP 402, SpEd 402) Behavior Modification (3)
Theory and applications of behavior modification methods in classroom and clinical settings. Methods derived from operant, classical, and cognitive models. Topics include behavior analysis, charting behaviors, outcome research, and ethical and philosophical issues. Prerequisite: HD 400 or its equivalent.

403. Cognitive Psychology (3)
Theoretical and empirical issues in cognitive psychology. Prerequisite: Graduate standing or consent of instructor.

404. Biopsychology (3)
Theoretical and empirical issues in biopsychology. Prerequisite: Graduate standing or consent of instructor.

405. Developmental Psychology (3)
Theoretical and empirical issues in developmental psychology. Prerequisite: Graduate standing or consent of instructor.

406. Personality Psychology (3)
Theoretical and empirical issues in personality psychology. Prerequisite: Graduate standing or consent of instructor.

409. Professional Seminar (1)
Two hours of class meetings per week of first- and second-year graduate students to discuss teaching psychology and preparing for the profession.

412. (BEB 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; body temperature regulation. Prerequisite: BEB 404 and consent of instructor. Schneider

414. (BEB 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: BEB 404 and consent of instructor. Simon

415. (BEB 415) Psychopharmacology (3)
Mechanism of drug action in the central nervous system. Cell surface receptors and second messenger systems. Drug use/abuse and cellular changes mediating behavioral effects. Drug use in clinical therapy. Prerequisite: BEB 404 and consent of instructor. Simon

420. (BEB 420) Pheromonal Communication (3)
Mechanisms of pheromone synthesis, biochemistry, sensory transduction, neuroanatomy/neuroendocrinology, and adaptive significance. Prerequisite: BEB 404 and consent of instructor. Nyby

421. Analysis and Design of Experiments (3)
First of a two-semester sequence covering a variety of issues in theoretical and applied statistics with emphasis on inferential statistics and analysis of variance. Richter

422. Analysis and Design of Experiments (3)
Continuation of Psyc 421. Prerequisite: Psyc 421. Richter

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: Psych 406. Williams, Wurf

435. Abnormal Psychology (3)
Theoretical and empirical analysis of issues regarding the nature, measurement, causes, and treatment of various forms of abnormal behavior. Williams

441. Communicating Psychological Concepts (3)
How to organize facts and ideas into broader meaningful units that are readily communicable. Includes media aids. Prerequisite: consent of the department chairperson. Newman

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

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

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.)

453. Advanced Topics in Learning (3)
An intensive study with emphasis on current research of discrimination learning, avoidance learning, concept learning, problem solving, or verbal learning. May be repeated for credit. Prerequisite: Psyc 403 or consent of instructor.

460. Special Study (1-3)
Study of some special topic not covered in the regular course offerings. May be repeated for credit.

461. Research Seminar (1-3)
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.

465. Teaching Internship (3-6)
The preparation and teaching of an undergraduate course with appropriate supervision by members of the faculty. Observation and evaluation of the intern via classroom visits and videotapes. May be repeated for up to six hours credit.

472. (BEB) Special Topics in Physiological Psychology (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: Psyc 404 or consent of instructor. Nyby, Schneider, Simon

473. (Coun 457) 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. Hyland, Williams

474. (Educ 474) Psychological Development in Childhood (3)
Survey of theories and research concerning perceptual, cognitive, social, and personality development through infancy and childhood. (Intended for graduate students in the College of Education.)

475. (Coun 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 problems. Prerequisite: admission to program in counseling.

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

478. (CogS 478) Ontological Psychology (3)
Principles and constraints for the modeling of psychological phenomena: perception, memory, knowing, emotions, consciousness, language, and rationality. Bickhard

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

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.

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

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

487. Seminar in Visual Perception (3)
Examination of selected topics of current interest in visual perception from behavioral, cognitive, and neurophysiological approaches. Prerequisite: Psyc 404 or consent of instructor.

Major Programs in Behavioral and Evolutionary Biosciences (BEB) and Behavioral Neuroscience (BNS)
Please see course listings for Behavioral and Evolutionary Biosciences (BEB), and the program description for Behavioral Neuroscience (BNS) under those headings in the catalog.

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 new 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 thirty credit hours of appropriate coursework satisfies all requirements.

Course Requirements. To complete the program, a student must complete ten, 3-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 graduate school 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.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>IE 332</td>
<td>Quality Control (3)</td>
</tr>
<tr>
<td>IE 328</td>
<td>Engineering Statistics (3)</td>
</tr>
<tr>
<td>IE 410</td>
<td>Design of Experiments (3)</td>
</tr>
</tbody>
</table>
### Description of Courses

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE 422</td>
<td>Measurement and Inspection Systems</td>
<td>(3)</td>
</tr>
<tr>
<td>IE 442</td>
<td>Total Quality Management</td>
<td>(3)</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
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<tbody>
<tr>
<td>IE 305</td>
<td>Simulation</td>
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<tr>
<td>IE 304</td>
<td>Production Engineering</td>
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<td>IE 405</td>
<td>Advanced Quality Control</td>
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<td>IE 409</td>
<td>Data Dependent Systems</td>
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<td>IE 415</td>
<td>Manufacturing Management</td>
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<td>IE 421</td>
<td>Nontraditional Manufacturing Processes</td>
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<td>IE 424</td>
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<td>IE 448</td>
<td>Industrial Control Systems for</td>
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<td>Engineering Project</td>
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<td>Mgt 409</td>
<td>Purchasing and Materials Management</td>
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<td>Math 338</td>
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<td>ME 446</td>
<td>Mechanical Reliability</td>
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</tbody>
</table>

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); Laurence J. Silberman, Ph.D. (Brandeis), Philip and Muriel Berman Professor of Jewish Studies, and Director of the Philip and Muriel Berman Center for Jewish Studies.

**Associate professors.** Kenneth L. Kraft, Ph.D. (Princeton); Michael L. Raposa, Ph.D. (Pennsylvania), Chairperson; Lloyd H. Steffen, Ph.D. (Brown); Lenore E. Chava Weissler, Ph.D. (Pennsylvania), Philip and Muriel Berman Chair of Jewish Civilization; 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 liberal 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 (involving historical and philosophical perspectives) and social scientific (involving sociological, anthropological, and psychological perspectives) modes of inquiry. 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 (8 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 five courses at the 100 level or above.

In addition to this minimum distribution, we recommend a concentration 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 admittance to honors, the student will work out a special program of studies for the senior year with the major advisor (typically involving special directed reading courses, a senior essay, etc.).

### Minor in Religion Studies

The minor in religion studies consists of a total of sixteen 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 departmental chairperson.
Course Offerings

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)

2. Life and Death in Religious Traditions (4)
Explores ways in which Eastern and Western religions conceptualize the great life passages, birth, maturation, marriage, parenting and death. Weissler. (HU)

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, corporal punishment (such as the death penalty), problems in medical ethics, and heavy drinking as a behavioral problem. Steffen (HU)

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

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)

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)

7. Jesus, Buddha, Confucius, and Elvis (4)
Comparative and cross-cultural exploration of the nature and meaning of "religious founders" in the history of religions. Girardot. (HU)

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)

64. (Asia 64) Religions of China (4)
History and meaning of the major forms of Chinese religion—especially Confucianism and Neo-Confucianism, Taoist mysticism, Buddhism (Ch'an/Zen), and popular religion. Girardot. (HU)

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)

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)

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 Rauschen Busch) 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)

73. The Jewish Tradition (4)
Development of traditional Judaism; readings in the Bible, the Talmud, and selected mystical 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)

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. (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)

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)

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 Patriarchs, the Exodus, the monarchy, prophecy, Exile and Return. Emphasis on historical, literary, critical problems, and newer socio-historical methods. (HU)

112. Varieties of Judaism 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)

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)

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)

129. (Phil 129) Jewish Philosophy (3)
How major Jewish thinkers from the 1st 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)

130. 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 as immanent in the world or transcending it, and between imagery for God and religious experience of God. Weissler. (HU)

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)

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)

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)

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)

142. Prehistoric Religion and Technology (4)
Origins and early development of religions, with focus on interactions of religion, magic, and technology, especially as these correlate with hunting, agriculture, and pastoral modes of subsistence. Girardot. (HU)

150. Judaism in the Modern World (4)
Fundamental themes in the experience of modern Jewry; confrontation with secular culture; crisis of religious faith; Zionism and the renewal of Jewish nationalism; the problem of Jewish identity in America; and the impact of the Holocaust. Silberstein, Weissler. (HU)

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)

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)

155. Jewish Thought since the Holocaust (4) Reactions to the Holocaust by major Jewish thinkers such as Wiesel, Rubenstein, Fackenheim, Buber, Herschel, Schulweis, and Berkovitz. Focus on the problem of evil and its relationship to religious faith. Silberstein. (HU)

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)

157. (Hist 157) The Renaissance and Reformation (3) 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)

158. (WS 185) 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)

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)

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 Tsu) and of the later religious tradition (e.g. Pao P'u Tsu and other selections from the Tao Tsang). Contemporary implications of Taoist thought will also be considered (e.g. "The Tao of Physics", "a Taoist on Wall Street", and "the Tao of Japanese Management"). Girardot (HU)


164. (Asia 164, IR 64) 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 US, the postwar American occupation, and contemporary issues. Readings include Japanese novels and short stories (in translation). Kraft. (HU)

168. (Asia 168) 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)

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)

174. Contemporary Theology (4) Major twentieth 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)

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)

181. (Phil 181) 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)

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)

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)

188. Religion and Literature (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)

189. Religion and the Visual Arts (4)
To what extent does the process and production of artistic images relate to visionary experience in the history of world religions, and expose a religious dimension in life? In what sense is an artistic vocation similar to the religious vocation of a shaman, prophet, or saint? In what way do artists and religious figures respond to, change, and create the "real" world? Girardot. (HU)

204. (MFL 204) The Myths of the Slavs: Folklore and Literature (3)
Distinction between "folklore" and "literature". Study of Russian, Ukrainian, and Belarussian tales, legends, riddles, sayings and heroic poems. Manouelian. (HU)

213. (Class 213) Ancient Roman Religion (3)

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)

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)

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. Prerequisite: Rel 181 or consent of the department instructor. Raposa. (HU)

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)

237. (Phil 237) Kierkegaard and Nietzsche (3)
Two maverick thinkers of the 19th century, concerned with religious faith, values, and the meaning of human existence. (HU)

251. (Class 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. (HU)

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. Frankel. (SS)

355. (Hist 355) European Intellectual History (3)
Political and religious thought and other aspects of the history of ideas in Europe from the Middle Ages to about 1700. Baylor. (HU)

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. Thomas. (SS)

361. Fieldwork (4)
Opportunity for students to work, or observe under supervision, religious organizations or institutions. Consent of chair required. (ND)

371. Directed Readings (1-4)
Intensive study in areas appropriate to the interests and needs of students and staff. (ND)
Russian

See listing under Modern Foreign Languages.

Russian Studies

Rajan Menon, Ph.D. (Illinios), Monroe J. Rathbone professor of international relations, program director.

Professors: Donald D. Barry, Ph.D. (Syracuse); Oles M. Smolansky, Ph.D. (Columbia).

Assistant Professor: Mary A. Nicholas, Ph.D. (Pennsylvania).

Adjunct Professor: Winfred Kohls, Ph.D. (Berkeley).

Lecturer: Edward Manouelian, Ph.D. (Harvard).

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 and Soviet culture. Courses in language, literature, history, politics, foreign policy, and economics, as well as the possibility of study in the USSR, 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 require 36-40 credit hours, distributed as follows:

A. Required Courses

I. Language and Literature: two years of college Russian, course selection based on placement: 12-16 credit hours.

II. Russian Literature: one course in Russian or in Translation

III. Russian History

Hist 261 A History of Russia to 1855 (3)
Hist 262 A History of Russia, 1855 to Present (3)

IV. Russian Politics and Foreign Policy

Govt 361 Soviet and Post-Soviet Politics (3)
IR 168 Diplomacy of Russia Since 1945 (3)

B. Elective Courses

The student will select at least three courses from the following list:

IR 167 Diplomacy of Russia to 1945 (3)
IR 367 Seminar in the International Relations of Russia and Eastern Europe (3)
Govt 318 Communist Political Systems (3)
Eco 309 Comparative Economic Systems (3)

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 merely to do focused work on the culture and society of the former USSR.

The minor in Russian Studies requires eighteen to twenty-two credit hours of formal course work, chosen in consultation with the program director, Donald Barry, department of Government.

required courses (15-19 hours)

two semesters of college-level Russian (at least three credit hours each), based on the student's level of competence; or two semesters of Russian literature in translation (6-10)

Govt 361 Soviet and Post-Soviet Politics (3)
Hist 261 A History of Russia to 1855 (3) or Hist 262 A History of Russia to Present (3)
IR 167 Diplomacy of Russia to 1945 (3) or IR 168 Diplomacy of Russia Since 1945 (3)

elective course (3 credit hours); one course from the following:

any other Russian-language course (3)
any other Russian literature course (3)
Govt 318 Communist Political Systems (3)
Eco 309 Comparative Economic Systems (3)
Hist 261 or 262 (whichever is not taken under Section I) (3)
IR 167 or 168 (whichever is not taken under Section I) (3)
IR 367 Seminar in the International Relations of Russia and Eastern Europe (3)
Special Topics courses in other areas such as psychology or social relations, with permission (3)
Field Study in the former Soviet Union for academic credit under Special Topics (3)

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 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.
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 intercollege 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 of 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 33 credit hours in STS courses, listed below, together with at least 18 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 and a suggested roster follows.

Detailed Description of STS Major Requirements

A. Required STS Courses (minimum of 33 hours)

STS 11: Technology and Human Values
STS 12: Engineering and Society
History 7: The Machine in America
STS/Jour 124: Politics of Science or Govt 115: Technology as Politics
Philosophy 128: Philosophy of Science or Philosophy 228: Topics in Philosophy or Science
Economics: 1, 11, or 12

B. Concentration in a complementary discipline (minimum of 18 hours to be chosen in conjunction with STS Studies advisor; or double major).

C. Science and Mathematics Requirement

Students must fulfill the College's regular B.A. distribution requirements of at least 8 credits in the Natural Sciences; and at least 3 credits in Mathematical Sciences. At least one of the courses in the Natural Sciences must also include the associated laboratory course. These courses should be chosen in consultation with the advisor.

Suggested STS Major Roster

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<th>Year 3</th>
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<td>English 2</td>
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<td>English 1</td>
<td>(3)</td>
<td>History 7</td>
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<td>Science Elective</td>
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<td>Math</td>
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<td>(3 or 4)</td>
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<td>STS 11</td>
<td>(3)</td>
<td>STS 12</td>
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<td>Collateral STS - 1</td>
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<td>STS 124/Jour 124</td>
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<td>or Govt 115</td>
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<td>Humanities Elective</td>
<td>(3)</td>
<td>Collateral STS-2</td>
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<td>Elective/Eco Course</td>
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<td>Philosophy 128 or 228</td>
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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 five courses (fifteen hours) clustered about one of three areas of concentration:
(1) science, technology and society;
(2) science, technology and human values;
(3) science, technology and culture.
Minors must take STS 11: Technology and Human Values. At least three of the five courses should be taken in one of the above areas, and at least one course in any other area.
A list of all courses eligible for STS Studies follows, divided according to concentration. Students should consult with the Program Director when selecting courses for either the major or the minor.

Science, Technology and Society Courses
11. Technology and Human Values (3)
Impact of technology on society in relation to ethical problems raised by the exploitation of technological innovations. Illustrations from literature, art, philosophy, history, folklore, and film. Cutcliffe. (SS)

12. Engineering and Society (3)
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)

121. Technology, Engineering and Public Policy (3)
The commercial nuclear power industry, civilian space programs and genetic engineering serve as vehicles for examining the interaction of political, social and personal values with technical knowledge in establishing research and innovation policies. Goldman. (SS)

124. (Jour 124) Politics of Science (3)
Organization of the U.S. scientific community and how it interacts with government, the mass media and the public. Friedman. (SS)

141. (Asia 141) Science and Technology Studies in East Asia (3)
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
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.

I. Science, Technology and Society

Anth 151 Utopias and Alternative Communities—Staff
CSc 252 Computers and Society—Barnes
Eco 311 Environmental Economics—Munley
Eco 314 Energy Economics—McNamara
EES 11 Environmental Geology—Evenson
Govt 111 The Politics of Environment and Natural Resources—Wurth
Govt 115 Technology as Politics—Wurth
SSP 135 Medicine and Society—Lasker
SSP 327/Jour 327 Mass Communication and Society—Rosenwein
Jour 125 Environment, Public, and Mass Media—Friedman
STSc 12 Engineering and Society—Goldman, Nagel
STSc 121 Technology, Engineering and Public Policy—Goldman
STSc/Jour 124 Politics of Science—Friedman
STSc 341 Issues in American Competitiveness—Goldman, Nagel

II. Science, Technology and Human Values

Engl 122 Speculative Fiction—Arlber
Engl 187 Themes in Literature: Utopian Literature—Harson
Mus 253 Composition I: Electronic and Acoustic Techniques—Salerni
Mus 254 Composition II—(Cont. of Mus 253)—Salerni
Psyc 65 Perception and The Visual Arts—Shortess
Psyc 165/Art 165 Perception and the Visual Arts Studio—Shortess
Phil 116 Medical Ethics—Staff
Phil 128 Philosophy of Science—Barnes
Phil 228 Topics in the Philosophy of Science—Goldman
Phil 250 Minds of Men and Robots—Melchert
RS 187 Science, Technology & The Religious Imagination—Raposa
RS 142/Anth 142 Prehistoric Religion and Technology—Girardot
STS 11 Technology and Human Values
Thtr 161 Theater Design and Engineering—Milet

III. Science, Technology and Culture

Arch 107 History of American Architecture—Thomas
Arch 210 20th-Century Architecture—Zaknic
Arch 361/Hist 361 Evolution of Highrise Building Construction—Peters
Arch 363/Hist 363 Evolution of Long-Span Bridge Building—Peters
Arch 365/Hist 365 Evolution of the Modern Building Process—Peters
Cls 108 Ancient Technology—Small
Clsc 204/Arch 204 Ancient City and Society—Small
Hist 7 Machine in America—Smith
Hist 31/Asia 31 History of Japanese Industrialization Since 1800—Cooper
Hist 107 Technology and World History—Smith
Hist 111 Engineering in the Modern World—Smith
Hist 307 History of American Industrial Technology—Smith
Hist 315 American Environmental History—Cutcliffe
STS 141/Asia 141 Science and Technology Studies in East Asia—Notis
STS/Hist 145 Introduction to the History of Science—Goldman
STS/Mat 221 Materials in the Development of Man—Notis

Social Psychology

See listings under Sociology and Anthropology.

Sociology and Anthropology

Professors. Raymond Bell, Ed.D. (Lehigh); Donald T. Campbell, Ph.D. (Berkeley), University Professor Emeritus of Social Relations and Psychology; Barbara B. Frankel, Ph.D. (Princeton), Emerita; John B. Gatewood, Ph.D. (Illinois); Roy C. Herrenkohl, Ph.D. (N.Y.U.); Judith N. Lasker, Ph.D. (Harvard), chairperson; James R. McIntoch, Ph.D. (Syracuse); Robert E. Rosenwein, Ph.D. (Michigan); Robert C. Williamson, Ph.D. (Southern California), Emeritus.

Associate professors. David B. Small, Ph.D. (Cambridge); Joan Z. Spade, Ph.D. (SUNY-Buffalo); Nicola Tannenbaum, Ph.D. (U. of Iowa).

Assistant professors. Patrice A. Teltser, Ph.D. (Virginia Polytechnic).

Lecturer. Ernest Green, Jr., Ph.D. (Pennsylvania).

The disciplines of sociology and anthropology are concerned with the study of human beings in relationships with others, i.e., with social relations. As such, these disciplines encompass
the study of the broadest range of human social activities, from the comparative examination of widely divergent 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. To study social relations is to develop an understanding of the influences that have shaped one's past and that pattern one's future.

The common goals of the department's diverse offerings are to foster both self- and societal-awareness and to provide students with the analytic skills necessary to understand and conduct social research. 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 (6 in 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.

**Fieldwork 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, and 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 chairperson should be consulted for further details.

**Departmental Honors.** To be eligible for departmental honors, students must have at least a 2.80 GPA overall and at least a 3.25 GPA in the major. In addition, students pursuing honors must take SR, Anth, or SSP 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 (6 credits, from two of the disciplines)**

- 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 6 credits of individualized study—371, 393, or 399 courses—can be applied toward this requirement.

#### Anthropology

**Introductory (6 credits)**

- Anth 11 Sociocultural Anthropology (3) spring
- 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 seven may be a SR, or SSP course.) No more than 6 credits of individualized study—371, 393, or 399 courses—can be applied toward this requirement.

#### Sociology/Social Psychology

**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 6 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  Fieldwork 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 11 or 12 and twelve additional credits at the 100-level or above in anthropology.
Social Psychology: SSP 21 and twelve additional credits at the 100-level or above in social psychology.
Social Relations: One introductory course (Anth 11 or 12, SSP 5 or 21) and twelve 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 twelve additional credits at the 100-level or above in sociology.

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. Green. (ND)

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 on 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. Fieldwork in Social Relations (1-3)
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 chairperson. (SS)
Anthropology

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 cultural theory. 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 peasant peoples who depend on small-scale agriculture and comprise 80% of the world population. Cultural, political, and economic bases of peasant society 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 139. (Rel 139) Jewish Folktore (3)
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. (HU)

Anth 140. (CogS 140, PsyC 140, MFL 140) Introduction to Descriptive Linguistics (3)
Relationship between language and mind; form and properties of language; language and society; how languages change over time. (SS)

Anth 142. (Rel 142) Prehistoric Religion and Technology (3)
Origins and early development of religions, with focus on interactions of religion, magic, and technology, especially as these correlate with hunting, agriculture, and pastoral modes of subsistence. Girardot. (SS)

Anth 151. Utopias and Alternative Communities (3) (s.s.)
Present and past searches for new forms of community in fact and fiction.

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 174, 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. (Clss 178) Mesoamerican Archaeology (3)
Ancient civilizations of Mesoamerica: Olmec, Zapotec, Maya, Toltec, and Aztec. Reconstructions of urban centers, political and economic organizations, and theories of the Mayan collapse. Small. (SS)

Anth 180. (Clss 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)

Anth 182. North American Indians (3)
Culture areas of native North America prior to substantial disruption by European influences north of Mexico. Environmental factors and cultural forms. Gatewood. (SS)
Anth 184. Cultures of the Pacific (3)
Cultures of the Pacific Islanders prior to substantial disruption by European influences. Culture histories, language families, social organizations, and religions of Australian, Melanesian, Polynesian, and Micronesian peoples. Gatewood. (SS)

Anth 186. Peoples of Island Southeast Asia (3)
Peoples and cultures of Malaysia, Singapore, Indonesia, Brunei, and the Philippines. Religions, world views, economies, and political forms. Tannenbaum. (SS)

Anth 188. Peoples of Mainland Southeast Asia (3)
Peoples and cultures of Burma, Laos, Cambodia, and Thailand. Religions, world views, economics, and political forms. 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 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 11, Anth 12, SSP 5, SSP 21, or department permission. Gatewood. (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 11, Anth 12, SSP 5, SSP 21, or department permission. Gatewood. (SS)

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 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 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

Anth 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 11, Anth 12, SSP 5, SSP 21, 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 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 chairperson. (SS)

Anth 376. Mind, Self and Culture (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 11, Anth 12, SSP 5, SSP 21, or department permission. Gatewood. (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 chairperson. (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 chairperson.

Sociology/Social Psychology

SSP 5. Introductory Sociology (3) fall
Social organization, stability and conflict, structure and function, and processes of social change in society. (SS)

SSP 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
Topics in sociology and social psychology. May be repeated for credit. (SS)

SSP 103. (AAS 103) Race Relations (3)
Racism, discrimination and prejudice, racial and ethnic conflict, and racial oppression in American society. Efforts by racial groups to improve their social conditions, e.g., the Civil Rights Movement. Focus on problems faced by Blacks, Hispanics, Native Americans, and Asians in contemporary United States. Thomas. (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 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 (3)
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. Green. (SS)

SSP 165. Contemporary Social Problems (3)
Studies of major problems facing contemporary society. (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 11, Anth 12, SSP 5, SSP 21, or department permission. (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 11, Anth 12, SSP 5, SSP 21, or department permission. Rosenwein. (SS)

SSP 314. (Psyc 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 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SSP 323. (Psyc 323) 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 11, Anth 12, SSP 5, SSP 21, or department permission. Herrenkohl. (SS)

SSP 325. (Hist 325, WS 325) American Social History, 1607-1877 (3) fall
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, WS 326) American Social History Since 1877 (3) spring
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 11, Anth 12, SSP 5, SSP 21, or department permission. Rosenwein. (SS)

SSP 333. (Govt 333, 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 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 11, Anth 12, SSP 5, SSP 21, or department permission. Spade. (SS)

SSP 351. (WS 351) Gender and Social Change (3)
Changes in gender roles from a social psychological and structural perspective. 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 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 11, Anth 12, SSP 5, SSP 21, or department permission. Spade. (SS)

SSP 356. (Psyc 356) Seminar in Personality Psychology (3)
Topics in personality psychology: the self, personality consistency, motivation, psychological adjustment. Prerequisite: SSP/Psyc 153 or consent of instructor. Williams, Wurf. (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 11, Anth 12, SSP 5, SSP 21, or department permission. Thomas. (SS)

SSP 361. (Psyc 361) Personality and Social Development in Adulthood (3)
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 (3)
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: Psyc 107 or 108 or SSP/Psyc 109 or consent of instructor. (SS)

SSP 364. (WS 364) Sociology of the Family (3)
Historical development of families in the U.S. and issues faced by contemporary American families, including parenting, combining work and family, and divorce and remarriage. Anth 363 recommended in conjunction with this course. Prerequisite: Any one of the following introductory courses: 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 11, Anth 12, SSP 5, SSP 21, or department permission. Spade. (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 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 chairperson. (SS)

SSP 373. Seminar in Sociology (3) (s.s.)
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 11, Anth 12, SSP 5, SSP 21, or department permission.
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 11, Anth 12, SSP 5, SSP 21, or department permission. (SS)

SSP 379. (AAS 379) Race and Class in America (3)
The nature of race and class in America and how these two organizing principles affect the lives of African Americans and other racial minorities. Issues related to the "race versus class" debate, with special attention to differences between the Black under-class and Black middle-class. Prerequisite: Any one of the following introductory courses: Anth 11, Anth 12, SSP 5, SSP 21, or department permission. Thomas. (SS)

SSP 391. (Psych 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 chairperson. 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 chairperson. (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 chairperson.

For Graduate Students
The department offers a master's (MA) degree program in social relations. This thirty-credit program provides further preparation for an advanced degree and training for nonacademic careers. Students may concentrate in (1) health, family, and human development, (2) human ecology and social structure, (3) analysis of interaction processes, or (4) a program tailored to individual educational needs. All graduate students complete the program with a thesis. In conjunction with the Center for Social Research the department offers many opportunities for research experience. For further information students should contact the department chair or graduate program director.

SR 401. Proseminar in Applied Social Research
Specialized topics including advanced statistical and measurement techniques, computing methods, data base management, research design and specialized areas of research activity. Can be repeated for credit. Permission of instructor required.

SR 411. Advanced Research Methods (3) fall
A basic course given in research theory and methods. Consideration given to the nature of theory, hypotheses testing, the definition of variables and methods of measurement.

SR 412. Practicum in Research Methods (3) spring
Laboratory in the design and execution of research. Includes class project. Prerequisite: SR 411.

SR 413. Fieldwork in Social Relations (3)
Supervised work experience in a variety of field settings, e.g., hospital, public and private social service agencies and organizations.

SR 414. Survey Research (3)
Examination of survey methods, sample design, interview design, training of survey personnel, data management and analysis.

SR 416. (Educ 416) Quasi-Experimentation and Program Evaluation (3)

SR 461. Seminar in Social Relations (1-4)
Topics in social relations: anthropology, sociology and social psychology. Topics vary.

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 social relations that is appropriate to the interests and needs of staff and students.

SR 472. Special Topics (1-3)
Continuation of SR 471.

SR 473. (Educ 473) Social Bases 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.

SR 477. Advanced Computer Applications (4) spring
Uses of computers in social sciences, including data collection, management, and analysis, simulations, and decision-making; includes weekly lab.
Spanish
See listings under Modern Foreign Languages.

Special Education
See listings under Education.

Speech
See listings as Communication under Journalism and Communication.

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), chairperson.
Instructor. Ardenie Hall, M.A. (Southwest Texas State).
Visiting assistant professors. Drew Francis, M.F.A. (Brandeis); Erica Hoelscher, M.F.A. (Northwestern).

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 or design. 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 Science.

The bachelor of arts degree in theatre is granted after at least thirty one credit hours of study. Because we believe 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. Some 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. Recent 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.

In addition to its academic courses, the department sponsors an active production program in which students, faculty and guest artists collaborate. Our main performance facility is the Wilbur Drama Workshop, a large, classic black box theatre. 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 separate lab theatre designed specifically for student 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.

Students interested in designing a major or minor in theatre should consult with the department chairperson. Experienced theatre students with questions regarding accurate placement in any theatre course should, likewise, consult with the chairperson.

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
GENERAL THEATRE STUDIES

The major in theatre consists of 39 hours distributed as follows:

Coursework required of all majors, 24 hrs
Thtr 61 Theatre Production (8)
(see production requirement)
Thtr 117 Theatre History (3)
Thtr 123 Dramatic Literature (3)
Thtr Acting (3) any appropriate level
Thtr Design (3) scenic, lighting or costume
Thtr 144 Basic Directing (3)
Thtr 315 Senior Study (1)

Electives, 15 hrs
Through the careful selection of theatre electives a student may emphasize acting/directing, design/technical theatre or general theatre studies.

Recommended electives from other departments:
The departments of Art and Architecture, Classics, English, Modern Foreign Languages, Music and others all offer
courses of value to a theatre major or minor. Consult with your advisor about scheduling these.

**Theatre Minor**
The minor in theatre consists of 19 credit hours selected in consultation with a departmental advisor. This includes 4 credits of Theatre Production or equivalent. See Production Requirement. Through the careful choice of courses students may create emphases in Acting/Directing, Design/Technical Theatre, or General Theatre Studies.

**The Production Requirement**
A theatre major is required to complete four ACTIVE SEMESTERS of production activity to complete the major. An ACTIVE SEMESTER is defined as a semester in which the student completes at least TWO CREDIT HOURS of approved coursework relating to Lehigh University Theatre productions. This may be accomplished a number of ways, including by taking Theatre 61, Theatre Production (2 hrs). This example is provided above in the section describing coursework required of all majors. Students completing Theatre 61, Theatre Production, for ONE CREDIT HOUR will complete ONE-HALF of an ACTIVE SEMESTER. Of the FOUR ACTIVE SEMESTERS required of the major, at least TWO must be completed in the junior or senior year. A student may complete ACTIVE SEMESTERS through other courses such as Theatre 185, Production Seminar (3), or Theatre 351, Advanced Special Projects (1-6). Of the FOUR ACTIVE SEMESTERS required, at least ONE ACTIVE SEMESTER must be awarded for off-stage activity. Majors should consult with the department every semester regarding APPROVED COURSEWORK for an ACTIVE SEMESTER of production activity.

Minors are required to complete TWO ACTIVE SEMESTERS of production activity.

**Departmental Honors**
The exceptional theatre 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. In 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 spring of that year the report or project would be executed. The student will enroll in two three credit honors courses, 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 chairperson 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.

**Thtr 11. Introduction to Acting (3)**
Discussion of text. Basic exercises and techniques. Preparation for scene study. Recommended for students with little or no prior experience.

**Thtr 15. Introduction to Design and Technical Theatre (3)**
Theatrical materials and methods. Basic concepts in scene design and stage lighting. Supervised practical experience.

**Thtr 61. Theatre Production (1-2)**
Supervised practical experience in theatrical production. May be repeated for credit. Prerequisite: consent of chairperson.

**Thtr 111. Theatre Sound (1)**
Techniques, materials, and methods of designing sound for theatrical production.

**Thtr 113. Stage Lighting (3)**
An introduction to the art and practice of lighting for the stage.

**Thtr 115. Scene Design (3)**
An introduction to the art of the scenic designer. History of design for the theatre. Materials, methods and techniques.

**Thtr 116. Stagecraft (3)**
Drafting, problem solving, stagecraft, rigging, materials and techniques. The role of the technical director.

**Thtr 117. Theatre History (3)**
Historical survey of western theatre from origins to present.

**Thtr 123. Directing (3)**
Introduction to the theatrical director's art. Scene work. Prerequisites: Thtr 117 or 123 and acting experience as determined by the department, or consent of chairperson.

**Thtr 144. Basic Directing (3)**
Introduction to the theatrical director's art. Scene work. Prerequisite: Thtr 117 or 123 and acting experience as determined by the department, or consent of chairperson.

**Thtr 147. Acting Early Modern Drama (3)**
Elements of characterization through scene study. Emphasis on work of early modern dramatists, e.g. Ibsen, Strindberg, Chekhov and others. Prerequisite: Thtr 11 or consent of chairperson.

**Thtr 148. Acting Modern European and American Drama (3)**
Elements of characterization through scene study. Emphasis on works of modern European and American dramatists, e.g. O'Neill, Williams, Brecht, Pirandello. Prerequisite: Thtr 11 or consent of chairperson.

**Thtr 151. Costume Design (3)**
The history and development of theatrical costuming. Wardrobe and its relationship to art and culture.

**Thtr 161. Theatre Design and Technology (3)**
Theatre environments, equipment systems and acoustics. Functions and ethics.

**Thtr 175. Special Projects (1-3)**
Theatrical topics of current or special interest, e.g., mime. Can be repeated for credit as title varies.

**Thtr 181. Theatre Management (3)**
Concepts, techniques and practices related to managing the theatrical enterprise.

**Thtr 185. Production Seminar (1-3)**
Practicum in various approaches to theatre production, e.g. ensemble. Prerequisite: consent of the chairperson. Can be repeated for credit as title varies.

**Thtr 214. Advanced Lighting (3)**
Continuation of Theatre 113. Lighting design for various performance forms. Practical experience. Prerequisite: Thtr 113.

**Thtr 216. Advanced Scene Design (3)**
Continuation of Theatre 115. Advanced design problems and techniques. Practical experience. Prerequisite: Thtr 115.

**Thtr 236. Acting Contemporary Styles (3)**
Elements of characterization and acting styles through scene study. Emphasis on works of current and recent dramatists, e.g. Pinter, Beckett, Trigiani, Mamet, Norman, Howe. Prerequisite: a 100-level acting course or consent of chairperson.

**Thtr 244. Acting Shakespeare (3)**
Acting problems from Shakespeare's dramatic and poetic cannon. Prerequisite: a 100-level acting course, or consent of chairperson.

**Thtr 245. Advanced Directing (3)**
Continuation of Theatre 144. Directorial approach. Supervised practical experience. Prerequisite: Thtr 144.

**Thtr 271. Playwriting (3)**
Techniques of the dramatist. The playwright's creative process. Practice in creating dramatic forms.

**Thtr 275. Internship (1-3)**
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 chairperson.

**Thtr 315. Senior Study (1)**
Seminar for senior theatre majors. Enhancement of current theatre studies while preparing for further theatre studies or activity. Fall only.

**Thtr 351. Advanced Special Projects (1-6)**
Independent study in theatre. Prerequisite: consent of the chairperson. Can be repeated for credit as title varies.

**Thtr 361. Research in Theatre Technology (1-3)**
Solving technological problems in theatre. Application of new technologies. May be repeated for credit. Prerequisite: consent of chairperson.
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. Barness, Ph.D. (Minnesota), professor of management; Frank T. Colon, Ph.D. (Pittsburgh), professor of government; Thomas J. Hyclak, Ph.D. (Notre Dame), professor of economics; Roger D. Simon, Ph.D. (Wisconsin) professor and chairman of history; J. Bruce Thomas, Ph.D. (Berkeley), assistant professor of architecture; Ivan Zaknic, M.Arch. and Urban Planning (Princeton) professor and chairman 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 existing and proposed public policies relating to cities.

A minimum of 33 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 (9 credit hours)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 61</td>
<td>The Study of Urbanization (3)</td>
</tr>
<tr>
<td>US 62</td>
<td>Contemporary Urban Issues (3)</td>
</tr>
</tbody>
</table>

one of the following research methods courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Govt 321</td>
<td>Research in Political Science (3)</td>
</tr>
<tr>
<td>Eco 145</td>
<td>Statistical Methods (3)</td>
</tr>
<tr>
<td>Hist 202</td>
<td>Introduction to Historical Research (3)</td>
</tr>
<tr>
<td>Math 12</td>
<td>Statistical Methods (3)</td>
</tr>
<tr>
<td>SR 111</td>
<td>Research Methods of Social Relations (4)</td>
</tr>
</tbody>
</table>

II. elective courses (24 credit hours)

Any course may be elected from among the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eco 312</td>
<td>Urban Economics (3)</td>
</tr>
<tr>
<td>Eco 337</td>
<td>Transportation and Spatial Economics (3)</td>
</tr>
<tr>
<td>Govt 177</td>
<td>Urban Politics (3)</td>
</tr>
<tr>
<td>Govt 360</td>
<td>Public Administration (3)</td>
</tr>
<tr>
<td>Hist 333</td>
<td>American Urban History to 1880 (3)</td>
</tr>
<tr>
<td>Hist 334</td>
<td>American Urban History, 1880 to Present (3)</td>
</tr>
<tr>
<td>Soc 370</td>
<td>Juvenile Delinquency (3)</td>
</tr>
<tr>
<td>US 363</td>
<td>Philadelphia: Development of a Metropolis (3)</td>
</tr>
</tbody>
</table>

Up to two Architectural History courses numbered 197 or higher

Up to two courses may be elected from among the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eco 354</td>
<td>Public Finance: State and Local (3)</td>
</tr>
<tr>
<td>Govt 331</td>
<td>Government and Law Internship (3)</td>
</tr>
<tr>
<td>Hist 326</td>
<td>American Social History Since 1877 (3)</td>
</tr>
<tr>
<td>US 125</td>
<td>American Ethnic Groups (3)</td>
</tr>
<tr>
<td>US 371/372</td>
<td>Special Topics (3-6)</td>
</tr>
</tbody>
</table>

Participants in off-campus programs, such as the Philadelphia or Washington semesters, may receive credit for up to three elective courses, depending upon the content of those courses, but they must also complete at least five courses in the first group of electives above.

Urban studies minor. The minor consists of US 61 and five additional courses from an approved list for a total of eighteen credit hours.

Undergraduate Courses

21. White Protestant Americans (3) spring, 1996

Cultural and religious origins of the historically dominant ethnic group in the United States; rise and decline of national Anglo-Protestant urban elite; persistence of regional and nonelite subcultures; "Wasp" stereotypes and anti-Protestant themes in American culture. Amidon. (SS)

26. The American Italian Community (3) spring, 1997

European background of Italian emigration; patterns of first-generation experience in the United States; distinctive values, folkways, and institutions; the "Mafia"; political behavior; upward mobility and assimilation; achievements of outstanding individuals; interaction with general American culture. Amidon. (SS)

28. The American Jewish Community (3) spring, 1998

Historical and sociological perspectives on the experience of an important minority in the United States; communal institutions and social patterns; orientation toward achievement and secular success; Jewish influences in American culture; anti-Semitism, acceptance, and survival as a distinct subculture. Amidon. (SS)

61. The Study of Urbanization (3) fall, 1995

Introduction to the study of cities. Emphasis on sources of economic vitality, especially entrepreneurialism, and on urban sociology. Some lectures on Bethlehem and Lehigh Valley history for illustrative purposes. Amidon. (SS)

62. Contemporary Urban Issues (3) spring, 1997
Analysis of problems, typically including planning, housing, and finance, with strong emphasis on twentieth-century New York City. Amidon. (SS)

125. American Ethnic Groups (3) fall, 1996
Immigration to the United States; persistence of cultural differences over generations; patterns of conflict and accommodation; assimilation; ethnic politics; emphasis on white Euro-American nationality groups; with some attention to Afro-, Hispanic-, Asian-, and native Americans. Amidon. (SS)

363. Philadelphia: Development of a Metropolis (3) spring, 1996
Philadelphia as an early experiment in the deliberate creation of a new community; the rise of the port; industrialization and immigration; creation of a hinterland and competition with rival centers; upper-class family continuity; religious life and institutions; political history. Amidon. (SS)

371,372. Special Topics (3-6)
A seminar on a topic of special interest in urban studies. Prerequisite: consent of the program director. (SS)

Women's Studies

Robin S. Dillon, Ph.D. (Pittsburgh), Director of Women’s Studies and associate professor of Philosophy.


Associate professors. Colleen M. Callahan, Ph.D. (North Carolina), associate professor of Economics; Lucy C. Gans, M.F.A. (Pratt), associate professor of Art and Architecture; Diane T. Hyland, Ph.D. (Syracuse), associate professor of Psychology; Jill E. Schneider, Ph.D. (Wesleyan), associate professor of Biological Sciences; Joan Z. Spade, Ph.D. (SUNY, Buffalo), associate professor of Sociology and Anthropology; Lloyd H. Steffen, Ph.D. (Brown), University Chaplain and associate professor of Religion Studies; Hannah W. Stewart-Gambino, Ph.D. (Duke), associate professor of Government; Nicola B. Tannenbaum, Ph.D. (Iowa), associate professor of Sociology and Anthropology; Lenore E. Chava Weissler, Ph.D. (Pennsylvania), Philip and Muriel Berman Chair of Jewish Civilization and associate professor of Religion Studies.

Assistant professors. Gail A. Cooper, Ph.D. (California-Santa Barbara), assistant professor of History; Patricia Turner, Ph.D. (Michigan), assistant professor of History.

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 (i.e., the social construction of differential identity for males and females) and of the many ways in which gender distinctions have shaped 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.

The minor in Women's Studies consists of a minimum of 18 credit hours (6 courses). 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 4 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)
WS 101 Introduction to Women's Studies (3)
And one of the following
WS 271 Independent Reading and Research (1-3)
WS 330 Internship in Women's Studies (3)
WS 350 Senior Seminar (3)
Elective Courses (12 credit hours)
WS 41/SR 41 Human Sexuality (3)
WS 121/Art 121 Women in Art (3)
WS 123/Anth 123 Cultural Construction of Gender (3)
WS 124/Hist 124 Women in America (3)
WS 126/Phil 126 Feminism and Philosophy (3)
WS 138/Rel 138 Women in Jewish History (4)
WS 152/Ciss 152 Women in Antiquity (3)
WS 158/Rel 158 Sex and Gender in Judaism: The Feminist Critique (4)
WS 179/Govt 179 Politics of Women (3)
WS 184/Rel 184 Religion, Gender, and Power (4)
WS 253/Hist 253 Women in European History, 1500-Present (3)
WS 311/Eng 311 Literature of Women (3)
WS 318/Psych 318 Seminar in Gender Psychology (3)
WS 325/Hist 325 History of Sexuality and the Family in the U.S. (3)
WS 326/Hist 326 Social Class in American History (3)
WS 341/Soc 341 Women and Health (3)
WS 351/Soc 351 Gender and Social Change (3)
WS 364/Soc 364 Sociology of the Family (3)
WS 91, 191, 272, 291, 371, 381, 382, 391, 392 Special Topics (1-3)

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 Elective Courses (12 credit hours)
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 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 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 122. (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 (3)
Roles of women in American society from colonial to present times; attitudes toward women, female sexuality, women's work, and feminism. Cooper, Shade. (SS)

WS 126. (Phil 126) Feminism and Philosophy (3)
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, sex roles and gender differences, sexism, femininity, sexuality, reproduction, mothering. Dillon. (HU)

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. Experience of modern Jewish women, and the contemporary feminist critique of traditional gender roles. Weissler. (HU)

WS 152. (Clss 152) Women in Antiquity (3)
Interdisciplinary study of women in Greece and Rome. Literary archaeological and historical evidence and approaches. Cross-cultural material. Phillips. (HU)

WS 158. (Rel 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, and marriage and divorce. Silberstein. (HU)

WS 179. (Govt 179) Politics of Women (3)
Major social and political issues relating to the role of women in American society. Study of other countries will be included for comparative analysis. Olson. (SS)

WS 184. (Rel 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)

WS 253. (Hist 253) Women in European History, 1500-present (3)
Examines the position of women in Europe since the Renaissance. Particular attention 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 distinction as reflected in law, politics, popular culture, and leisure. Turner. (SS)

WS 311. (Engl 311) Literature of Women (3)
Women's works about women: is literary creativity gender-identified? Are there specifically "feminine" subjects or themes? Besides re-reading some familiar fiction, drama, and poems, introduction to contemporary and often experimental works by less famous writers. Arbur. (HU)

WS 318. (Psych 318) Seminar in Gender Psychology (3)
Gender as shaped by psychological and social psychological processes. Socialization, communication and power, gender stereotypes, methodological issues in sex differences research. Prerequisite: Psych 210 or permission of instructor. Hyland. (SS)

WS 325. (Hist 325, SSP 325) History of Sexuality and the Family in the U.S. (3)
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. Soderlund, Shade. (SS)

WS 326. (Hist 326, SSP 326) Social Class in American History (3)
Emphasis on the 19th and 20th centuries, focusing on: emergence of a white collar middle class; conditions 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 the extent of social mobility. Simon. (SS)

WS 341. (Soc 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: an introductory department course (Anth 11, Anth 12, SSP 5, or SSP 21), or consent of the department chair. Lasker. (SS)

WS 351. (Soc 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: an introductory department course (Anth 11, Anth 12, SSP 5, or SSP 21), or consent of the department chair. Spade. (SS)

WS 364. (Soc 364) Sociology of the Family (3)
Historical development of families in the U.S. and issues faced by contemporary American families, including parenting, combining work and family, and divorce and remarriage. Anth 363 recommended in conjunction with this course. Prerequisite: an introductory department course (Anth 11, Anth 12, SSP 5, or SSP 21), or consent of the department chair. Spade. (SS)

WS 91, 191, 272, 292, 371, 381, 382, 391, 392. Special Topics (1-3)
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 to 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 Science, 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 School in these colleges and in the College of Education. There are undergraduates from nearly every state and U.S. territory and more than forty 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 new 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 non-academic 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 deigned 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 minister et interpres 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 1971, the university opened its undergraduate program to them as well. Today men and women applicants are considered on an equal basis, and in the class that entered in 1986 more than 35 percent of the students were female.

From the first, the students were serious-minded. In 1924, Catherine Drinker Bowen, daughter of president Drinker and later 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 that 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 Lamberton (1880-1893). Lamberton, 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-Ullmann 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 Lamberton 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 the 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. Academically, during the Whitaker years 120 departments offered the master's degree and twelve the doctor of philosophy.

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.

Dr. Neville, a strong supporter of research who fostered its growth on the campus, died in 1983.

**Deming Lewis** (1964-1982). Willard Deming Lewis became president after a distinguished career as a space engineer and research administrator.

Dr. Lewis comes from a remarkable family that traces its American roots to William Lewis, an Englishman who settled in the Massachusetts Bay Colony in 1640. His great-grandfather and grandfather were presidents of the Lewis Manufacturing Co., a textile firm in Walpole, Mass. Willard Lewis, Deming's father, moved to Augusta, Ga., and eventually became owner of Riverside Mills there.

Deming was admitted to Harvard at age fifteen, but his mother thought him too young to attend. So he waited and entered Harvard at age sixteen, eventually receiving three degrees there, as well as two degrees from England's Oxford University, where he was a Rhodes Scholar in advanced mathematics. At Harvard, Lewis worked with Ted Hunt, the father of high fidelity, writing the equations describing a stylus sliding through a warped groove.

In 1941, Lewis joined Bell Telephone Laboratories, and in 1962 he was one of four executives who initiated Bellcomm, Inc., in Washington, D.C., which engineered systems for the Apollo project that placed the first man on the moon.

Lewis, who died in 1989, holds thirty-three U.S. patents on such devices as microwave antennas and filter and digital error detection systems.

During the Lewis administration, undergraduate women were admitted in 1971, and the university's visiting committees were established in 1964. New programs included majors in natural science, biology, social relations, geological sciences, environmental science and resource management, and religion studies. Minors for engineering students in such fields as business, history, and social sciences were begun. Interdisciplinary majors such as computer engineering, computing and information science, applied mathematics, management science, American studies, and many others were instituted. Six research centers and seven institutes were established, including the Biotechnology Research Center.

The first phase of the New Century Fund capital campaign yielded $11 million more than its goal of $30 million; the second phase, which brought the campaign to a conclusion in 1985, raised more than $100 million.

Construction included the following: Maginnes Hall; Whitaker Laboratory; Mart Science and Engineering Library; the Central Heating and Refrigeration building; Sinclair Laboratory; the Seeley G. Mudd Building and Neville Hall; Rathbone Hall dining room; thirteen fraternity houses, the Centennial I and Centennial II residential complexes; the Trembley Park student apartment complex; the Saucon Village Apartments complex, completion of the acquisition of the Saucon Valley athletic lands and the construction there of the Varsity House, the squash courts, the Philip Rauch Field House and Shabler Athletic and Convocation Center; and Brodhead House, a six-story residence hall. In addition, the restoration of Packer Memorial Church was completed, as well as a million-dollar renovation of Packard Laboratory.

Plans were made for the E. W. Fairchild-Martindale Library and Computing Center.

The original Physics Laboratory is now named in Dr. Lewis's honor.

**Dr. Peter Likins** (1982-present). Dr. Likins became eleventh president in 1982. Under his guidance Lehigh continues to seek balanced excellence in undergraduate programs while pursuing focused objectives in graduate study and research.

The Likins presidency has been characterized by achievement and action. In 1986, for example, Lehigh completed construction and implementation of its state-of-the-art telecommunications system, a $20-million plus project. As a result, all university buildings and residential facilities are wired to allow students and faculty maximum access to information and each other via the voice-and-data telecommunications network. Completion of the network approximately coincided with the dedication in 1985 of the E.W. Fairchild-Martindale Library and Computing Center,
which affords to the campus community one of the most automated library facilities available anywhere.

In 1986, a building adjoining the campus, at 200 W. Packer Ave., was named the Harold S. Mohler Laboratory, honoring the former chairman of the board of trustees. The building has been renovated to accommodate the Lehigh programs in Manufacturing Systems Engineering. The building also houses the Industrial Engineering Department.

In the fall of 1986, a dedication was held for the Sherman Fairchild Center for the Physical Sciences, an outstanding facility encompassing the renovated 1890s-era Physics Building (renamed Lewis Lab in 1994), the contemporary Sherman Fairchild Laboratory, and a new structure linking the two and providing an imposing entrance to physics facilities. The new building includes a 260-seat auditorium.

Also in 1986, the university purchased research facilities and land from Bethlehem Steel Corp. to establish what is now called the Mountaintop Campus, an area southeast of the Packer Campus and north of the Murray H. Goodman Campus, that links both campuses. The acquisition of five buildings and 742 acres at a cost of $18.75 million was the largest real estate transaction in the history of the university. Campus acreage virtually doubled.

Likins led the way in the establishment of the Colonial League, now the Patriot League, in football, effective with the 1986 season. Other schools belonging to the league are Bucknell, Colgate, Davidson, Holy Cross, Lafayette, the United States Military Academy and Fordham University. The league represents a commitment by participating schools to the principle of "scholar-athletes," students who are primarily concerned with academic work but who also play football. This principle has been a Lehigh tradition. Eventually, the member schools all will play each other every year, while also including all Ivy League schools in their schedules.

The university completed in 1989 a new stadium for football and other sports on the Murray H. Goodman Campus. Taylor Stadium has been razed to make way for the Rauch Business Center and the Zoellner Arts Center and garage.

Under Likins, financial support of the university has grown from around $10 million annually to more than $24 million in both 1986-87. In the years 1986 through 1990, 60 percent of alumni made gifts to Lehigh, placing Lehigh just behind first-place Dartmouth and just ahead of Princeton in percentage of alumni making gifts. The three schools are the leaders among Ph.D.-granting institutions for which records are kept on a national basis.

Likins was a prime mover in the establishment in 1984 of the Lehigh Valley Center for Jewish Studies, headquartered at Lehigh and serving private colleges in the area, and the establishment of a chair in Judaica based at Lehigh supported by a major gift from Philip and Muriel Berman.

In recent years, Lehigh established a center in the field of integrated circuits, the Center for Innovation Management Studies, the Chemical Process Modeling and Control Research Center, and the Center for International Studies.

A native of California, Likins is relaxed and informal in his interpersonal dealings and has regular personal contact with undergraduates. A former collegiate wrestler of some note (in 1982 he was named to the National Wrestling Hall of Fame), he and members of his family regularly attend Lehigh athletic events.

Likins was substantially involved in the university's designation as home of the North East Tier Ben Franklin Advanced Technology Center, one of four such centers established by the Pennsylvania legislature. The North East Tier center has assisted dozens of fledgling businesses involved in high-technology fields.

Dr. Likins is a distinguished academic administrator, a seasoned educator in engineering, an expert in spacecraft dynamics and control, an author of textbooks in engineer-ing mechanics, a researcher who continues to add to his substantial list of publications, and a consultant to governments and industry. He was one of 13 science advisors to President George Bush, serving on the president's science advisory committee.

He earned the B.S. in civil engineering from Stanford University in 1957, the master of science in civil engineering from Massachusetts Institute of Technology the following year, and the Ph.D. in engineering mechanics from Stanford in 1965. He joined Columbia as dean of the School of Engineering and Applied Science in 1976 and was named a provost in 1980. Earlier, he was a development engineer at the Jet Propulsion Laboratory of the California Institute of Technology, and subsequently served as professor and later as associate dean of engineering at the University of California, Los Angeles. He is a fellow of the American Institute of Aeronautics and a member of the National Academy of Engineering.

Dr. Likins and his wife, Patricia, have six children and reside in the President's House.

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 new Murray H. Goodman Stadium (dedicated in 1988) 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 an 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 Office of Community Relations, Iacocca Institute Offices, and 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 high-rise 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), an indoor tennis facility (1994), and the new Ulrich Student Center in Grace Hall.

Under construction just east of the Rauch Business Center is the new Zoellner Arts Center, which, when it opens in January of 1997, will house a 1000-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 opens this fall on the same site.

Altogether, the three campuses contain 130 buildings with more than 3 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 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, 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.

Observance of the centennial year took place in 1987.

President's House (1868). This 21-room residence, designed by Edward Potter, is the home of university presidents. Dr. and Mrs. Peter Likins and family have occupied the dwelling since 1982.

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 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 ACS.

The Department of Art and Architecture, division of Urban Studies, and Department of Psychology, the office of Lehigh University Art Galleries and the Department of Theatre 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 the office of Career Services.

Coppee 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. Coxe, pioneer mining engineer and trustee of the university. The building is now the headquarters of 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 Learning Center.

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 seven-story 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 Engineering.

Iacocca Hall. Known as the tower building, it houses the College of Education, the Chemical Engineering Department, the Biological Sciences Department, the Biotechnology and Bio processors Institute as well as a dining room and food service facilities, plus a teleconferencing classroom. There is also a library wing with Community Relations & Iacocca Institute offices on the mezzanine level. The Cities in Schools, Inc. hypermedia lab training facility is also housed here.

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 Women's Resource Center and the Office of Continuing Education and Summer Sessions. 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 houses the Music Department and related organizations.

Maginnes Hall (1970). The multilevel structure is headquarters for the College of Arts and Science and also houses the departments of Modern Foreign Languages, History, Government, International Relations, 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 newly renovated 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 as 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 Reese 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). 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.

**Sayre Observatory** (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 Graduate Admissions, International Education Office and the Office of the Vice President for Research are located in the building.

**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 & Environmental Sciences. A small greenhouse adjoins the building. The building was extensively renovated and a fourth story added in 1956 following a fire.

**Athletic and Convocational Facilities**

**Murray H. Goodman Stadium** (1988). 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.

**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. The upper level houses the newly renovated Ulrich Student Center, including movie theatre, gameroom and mailboxes.

**Indoor Tennis Facility** (1994). An anonymous donor made possible the construction of four indoor tennis courts for recreational use as well as team practice.

**Philip Rauch Field House** (1976). Philip Rauch, '33, 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 and Convocation Center** (1979). This arena provides seating for 6,000 persons for concerts, spectator sports, and other events. University trustee Donald
B. Stabler, '30, made a major financial contribution toward the facility.

**Taylor Gymnasium** (1913 and 1904). 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, a fitness center, a men's & women's locker room, two racquet and two squash courts, and a steam room. The department of Intramural Sports, Recreation, Sports Medicine and Athletic Department Offices are housed here. Renovations are underway in the Hall of Fame and Sports Medicine areas.

**Varsity House** (1963). The building houses lockers for varsity teams. It is located on the Murray H. Goodman Campus.

**Wilbur Drama Workshop** (1908). During most of its life, the building served as a power plant. Renovated during the 1970s, it provides performing space for student theatrical productions.

**Power Facility**
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, the Manufacturers Resource Center, and the Agility Forum.

**Residential Facilities**
The university is primarily residential in character, with about 85 percent of undergraduates living in facilities on the campus, including university-operated residence halls and independently managed fraternity and sorority houses.

Approximately 1,825 students live in on-campus residence halls and apartments.

**Residence Halls**

**Brodhead House** (1979). This structure, the university's first high-rise residential facility, houses 190 students. The six-story building includes student 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 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.

**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 finished 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 four residence halls is located on Warren Square and Summit Street. They are upperclass facilities and 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.

**Stevens House.** The Rt. Rev. William Bacon Stevens, of Philadelphia, was Protestant Episcopal bishop of the Diocese of Pennsylvania and first president of the university board of trustees. He was the principal architect of the university's original academic plan.

**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 Science, 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 1,200 men live in fraternities.

Most of the fraternities have houses located in Sayre Park, while a few 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. A second year in the first column indicates reestablishment. 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 Founded</th>
<th>Year Moved to Present House</th>
<th>Additional Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha Chi Rho</td>
<td>1918</td>
<td>1968</td>
<td></td>
</tr>
<tr>
<td>Alpha Sigma Phi</td>
<td>1929</td>
<td>1961</td>
<td></td>
</tr>
<tr>
<td>Alpha Tau Omega</td>
<td>1966</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beta Theta Pi</td>
<td>1891</td>
<td>1968</td>
<td></td>
</tr>
<tr>
<td>Chi Phi</td>
<td>1872</td>
<td>1922</td>
<td>1968</td>
</tr>
<tr>
<td>Chi Psi</td>
<td>1893</td>
<td>1916</td>
<td>1955</td>
</tr>
<tr>
<td>Delta Chi</td>
<td>1952</td>
<td>1968</td>
<td></td>
</tr>
<tr>
<td>Delta Phi</td>
<td>1884</td>
<td>1963</td>
<td></td>
</tr>
<tr>
<td>Delta Sigma Phi</td>
<td>1931</td>
<td>1971</td>
<td></td>
</tr>
<tr>
<td>Delta Tau Delta</td>
<td>1874</td>
<td>1985</td>
<td>1959</td>
</tr>
<tr>
<td>Delta Upsilon</td>
<td>1885</td>
<td>1968</td>
<td></td>
</tr>
<tr>
<td>Kappa Alpha</td>
<td>1894</td>
<td>1961</td>
<td></td>
</tr>
<tr>
<td>Kappa Sigma</td>
<td>1900</td>
<td>1973</td>
<td></td>
</tr>
<tr>
<td>Lambda Chi Alpha</td>
<td>1926</td>
<td>1973</td>
<td></td>
</tr>
<tr>
<td>Phi Delta Theta</td>
<td>1876</td>
<td>1919</td>
<td>1963</td>
</tr>
</tbody>
</table>

There are eight sororities. All are nationally affiliated. Six reside in the Centennial I Complex and two reside in the Sayre Park. Some 360 women live in sororities.

The sororities are listed with year of establishment at Lehigh in the first column and year of moving into their present house in the second column.

<table>
<thead>
<tr>
<th>Sorority</th>
<th>Year Founded at Lehigh</th>
<th>Year Moved to Present House</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha Chi Omega</td>
<td>1901</td>
<td>1988</td>
</tr>
<tr>
<td>Alpha Gamma Delta</td>
<td>1975</td>
<td>1985</td>
</tr>
<tr>
<td>Alpha Omicron Pi</td>
<td>1983</td>
<td>1986</td>
</tr>
<tr>
<td>Alpha Phi</td>
<td>1975</td>
<td>1984</td>
</tr>
<tr>
<td>Delta Gamma</td>
<td>1982</td>
<td>1987</td>
</tr>
<tr>
<td>Delta Zeta</td>
<td>1988</td>
<td>1993</td>
</tr>
<tr>
<td>Gamma Phi Beta</td>
<td>1975</td>
<td>1985</td>
</tr>
<tr>
<td>Kappa Alpha Delta</td>
<td>1984</td>
<td>1986</td>
</tr>
</tbody>
</table>

### Centennial I Complex (1965)
Congdon House. Dr. Wray H. Congdon served as dean of students, dean of the graduate school, and special assistant to the president. Alpha Phi sorority is housed in Congdon.

Emery House. It is named for Dr. Natt M. Emery, who was vice president and controller. Gamma Phi Beta 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. His grandson, Dick Thornburgh, completed his second term as
governor of Pennsylvania at the end of 1986. Delta Gamma sorority is housed in Thornburg.

Delta Zeta sorority is housed in the former Sigma Phi Epsilon fraternity house.

Alpha Chi Omega sorority is housed in the former Theta Delta Chi 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 sylvania 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 built in 1757 by John Gottlob Klemm. The community's first settlers thirty years before the founding of the nation.

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
An Overview From Past to Present

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 St. Francis de Sales, Moravian, Muhlenberg, and Cedar Crest. A cooperative program is maintained that allows cross-registration for courses as well as shared cultural events. There are also two community colleges in the area.

In August 1984, Bethlehem held its first Musikfest, a 10-day annual festival that features a variety of musical performances and ethnic foods. An instant success, Musikfest was the brainchild of Jeffrey A. Parks, a lawyer and 1970 Lehigh graduate.
VII.
Administration, Faculty and Staff

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.

Board of Trustees

When the year of the degree is listed, the degree was awarded by Lehigh University.

Officers of the Board
William C. Hittinger, chair
Eugene Mercy, Jr., vice chair
Denise M. Blew, corporate secretary and treasurer
Richard H. Sanders, assistant treasurer

Members of the Board
Curtis H. Barnette, J.D. Yale, chairman & CEO, Bethlehem Steel Corp.
Patricia M. Battin, B.A., Swarthmore; M.S., Syracuse, retired president, Commission on Preservation & Access
Charles W. Brown, Jr., B.S. in Economics '77, general manager, AT&T
Kevin L. Clayton, B.A. '84, M.B.A. St. Joseph's University, senior vice president, Trust Company of the West
William L. Clayton, B.S. '51, senior vice president, Smith Barney
Phyllis A. Errico, '81 B.A., '84 J.D., assistant county attorney, County of Henrico, Richmond, VA

John J. Fioretti, B.S. '86, portfolio manager, Starbare Associates
Murray H. Goodman, B.S. '48, chairman, The Goodman Company
William F. Hecht, B.S. '64, M.S. '70, president and chief executive officer, Pennsylvania Power & Light
William C. Hittinger, B.S. '44, Eng.D. '83, retired executive vice president, research and engineering, RCA Corp.
Ronald R. Hoffman, B.S. '54, executive vice president, Human Resources, Aluminum Company of America
Douglas C. Lane, B.S. in Finance '67, M.B.A., University of Michigan, Lane Capital Management, Inc.
Peter Likins, university president/trustee ex officio
Gina H. McBean, B.A. '82, Fundraising & Community Relations Officer, the State Museum of Pennsylvania
Eugene Mercy, Jr., B.S. '59, chairman, Granite Capital International Group
James M. Miller, III, B.S. '65, M.B.A. '70, President, Argyle Capital Management
H. Edward Muendel, B.A. '64, president, Stanton Chase International
Diana T. Murray, B.A., Cornell, M.S., Columbia, director-corporate development, Sanus/New York Life
Robert B. O'Brien, Jr., B.A. '57, Printon, Kane Group, Inc.
Philip R. Peller, B.S. '60, partner, Arthur Andersen & Co.
Joseph R. Perella, B.S. '64, M.B.A., managing partner, Morgan Stanley Group, Inc.
John W. Puth, B.A. '52, J. W. Puth Associates
James R. Rice, B.S. '62, M.S. '63, Ph.D. '64, professor engineering science and geophysics dept., Harvard University, Cambridge, MA
Stanley M. Richman, B.S. '55, vice president, Lightning Electric Co.
C. Keith Rust, B.S. '57, president, Roland & Roland Inc.
Edwin F. Scheetz, Jr., B.S. '54, chairman, Guyasuta Investment Advisors, Inc.
Francis H. Spiegel, '57 B.S., '64 C.P.A., retired executive vice president, Merck & Co., Inc.
Donald B. Stabler, B.S. '30, M.S. '32, LL.D. '74, president & board chairman, Stabler Companies Inc.
Karen L. Stuckey, B.S. ’75, Partner, Price Waterhouse
Ronald J. Ulrich, B.S. ’67, M.B.A., New York University, President, Equinox Capital Management
Ronald H. Vaughn, B.S. ’59, President, NEAPCO.
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., ’63 B.S., vice chairman, Wesray Capital Corporation
Joseph F. Welch, B.S. ’56, chairman, J.F. Welch Interests, Inc.

Trustees Emeriti
Morgan J. Cramer, ’28, retired president, P. Lorillard and Co.
William B. Eagleson, Jr., B.S. ’49, M.B.A., retired chairman emeritus, Mellon Bank
Frank C. Rabold, B.S. ’39, Eng. D. ’70, retired manager of corporate services, Bethlehem Steel Corp.
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

Committees of the Board
Executive committee. Mr. Hittinger, chair; Ms. Battin, the Messrs. Clayton, Mercy, Perella, Richman, Scheetz, Speigel, Stabler, Ulrich, and Walsh, members.
Academic affairs committee. Mr. Spiegel, chair; Ms. Battin, vice chair; the Messrs. Barnette, Diamond, Mercy, Rice, Wagner, and Ms. McBean, members.
Graduate Studies & Research Subcommittee. Ms. Battin, chair; the Messrs. Diamond and Rice, members.
Advancement committee. Mr. Clayton, chair; Mr. Ulrich, vice chair; the Messrs. Diamond, Goodman, Mercy, Perella, Stabler, Vaughn, and Welch, members.
Audit committee. Mr. Peller, chair; Ms. Murray, and Ms. Stuckey, members.
Finance committee. Mr. Walsh, chair; Mr Lane, vice chair; the Messrs. Clayton, O’Brien, Peller, Perella, and Ms. Murray, members.
Investment subcommittee. Mr. Lane, chair; the Messrs. Clayton, Richard H. Francis, Steven K. Kreider, David B. Salerno, R. Charles Tschampion, III, and William D. Washyclym, members.

Nominating committee. Mr. Hittinger, chair; the Messrs. Mercy, Michael G. Bolton, Donald H. Bott, Ms. Errico and Ms. Stuckey, members.
Physical planning and plant committee. Mr. Richman, chair; Mr. Rabold, vice chair; the Messrs. Goodman, Hecht, Miller, Puth, Rust, Stabler, and Welch, members.
Student affairs committee. Mr. Scheetz, chair; Mr. Hoffman, vice chair; the Messrs. Brown, Clayton, Ehlers, Fioretti, Hoffman, Muceniel, Ulrich, Vaughn, and Ms. Errico, members.

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
Peter Likins, Ph.D., president
758-3157
Alan W. Pense, 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
Michael G. Bolton, M.B.A., vice president for advancement
758-3121
Denise M. Blew, B.S., CMA, CPA, treasurer
758-3179
James A. Tiefenbrunn, M.B.A., assistant vice president for budget
758-4204
Roy C. Herrenkohl, Ph.D., vice provost for research and dean of graduate studies
758-4210
Patti T. Ota, Ph.D., vice provost for academic administration and planning and associate to the president
758-3165
James W. Schmotter, Ph.D., dean, College of Business and Economics
758-3402
Harvey G. Stenger, Ph.D., dean, College of Engineering and Applied Science
758-5308
Joan Straumanis, PhD, dean, College of Arts and Sciences
758-4570
Alden J. Moe, Ph.D., dean, College of Education
758-3221
Anthony L. Corallo, M.A., assistant vice president for facilities services and campus planning
758-3970
Joseph D. Sterrett, Ed.D, Assistant Vice President
and Director of Athletics
758-4320
John W. Smeaton, PhD, Assistant Vice
President of Student Affairs
758-4156
Patricia G. Boig, B.A., Director of Admissions
758-3100
Arnold Hirshon, Vice Provost for Information Resources
758-3025
Roger N. Nagel, Ph.D., executive director,
laocca Institute
758-5452

College Officers
College of Arts and Sciences
Joan Straumanis, Ph.D., dean
Howard R. Whitcomb, Ph.D., associate dean
Gary G. DeLeo, Ph.D., associate dean
758-3300

College of Business and Economics
James W. Schmotter, Ph.D., dean
Therese A. Maskulka, D.B.A., associate dean
Kathleen A. Trexler, M.B.A., assistant dean and director,
MBA program
758-3402

College of Engineering and Applied Science
Harvey G. Stenger, Ph.D., dean
Richard N. Weisman, Ph.D., associate dean
758-4025

College of Education
Alden J. Moe, Ph.D., dean
758-3221

Offices and Resources
In this section, only the principal officers, are listed. For
degree information, consult the alphabetical listing that
follows.

Administrative Systems
8B E. Packer Avenue; 758-3010
Roy A. Gruver, director

Admission
27 Memorial Drive, West; 758-3100
Patricia G. Boig, director

Alumni Association
27 Memorial Drive, West; 758-3135
Barbara A. Turanchik, executive director

Art Galleries
17 Memorial Drive, East; 758-3615
Ricardo Viera, director

Athletics and Recreation
641 Taylor Street; 758-4300
Joseph D. Sterrett, director

Bookstore
9 W. Packer Avenue; 758-3375
Michael J. King, director

Budget
27 Memorial Drive, West; 758-4204
James A. Tiefenbrunn, assistant vice president for budget
Stephen J. Guttman, budget manager

Bursar
27 Memorial Drive, West; 758-3160
Craig F. Wood, bursar

Business Services
203 E. Packer Ave.; 758-3840
Barry L. Gaal, assistant vice president

Career Services
14 E. Packer Avenue; 758-3710
Marilyn Mackes, director

Mailing and Printing Services
118 ATLSS Drive; 758-5402-Mailing; 758-5408- Printing
Nancy Mariano, director

Chaplaincy Services
36 University Drive; 758-3877
Rev. Dr. Lloyd H. Steffen, university chaplain and professor
of religion studies

Community and Government Relations
118 Research Drive; 758-3885
Marcia Theodoredis, director

Computer Store
524 Brodhead Ave.; 758-4606
Robert R. Kendi, manager

Computing Center
8B E. Packer Avenue; 758-3830
William R. Harris, director

Conference Services
63 University Drive; 758-5306
Jessica Dunlap, manager

Controller
27 Memorial Dr., West; 758-3140
Robert E. Siegfried, controller
Janet S. Simek, associate controller

Counseling Service
36 University Drive; 758-3880
Ian T. Birky, director

Distance and Summer Studies
36 University Drive; 758-3935; 758-3966
James A. Brown, director

Office of Student Life
29 Trembley Drive; 758-4156
Mark H. Erickson, dean of students
Terrence M. Curran, associate dean of student life
Jennifer F. Volchko, associate dean of student life
Development/University Relations
27 Memorial Dr., West; 758-3120
Michael G. Bolton, vice president for advancement
John T. Fulton, assistant vice president for development

Facilities Services
461 Webster St.; 758-3970
Anthony L. Corallo, assistant vice president for facilities services and campus planning
Gary A. Falasca, director, office of facilities services
Patricia A. Chase, director, facilities planning and renovations

Financial Aid
218 W. Packer Avenue; 758-3181
William E. Stanford, director

Forum
29 Trembley Drive; 758-4190
Gray Bebout, interim chairperson; 758-5831

Fraternity Management Association
219 Warren Square; 758-3888
Linda S. Guerriere, executive director

Health Center
36 University Drive; 758-3870
Stanley L. Yellin, M.D., director

Human Resources (Personnel)
428 Brodhead Ave.; 758-3900
Edward R. Maclosky, director

Institutional Purchasing
203 E. Packer Ave.; 758-3840
Joseph F. Hardenberg, manager

Internal Audit
27 Memorial Drive, West; 758-5012
Robert J. Eichenlaub, director

International Education
5 E. Packer Avenue; 758-4859
Anne Thomas, director
C. Sowa, program officer, Lehigh Abroad; 758-3351

The Learning Center (Center for Writing, Math and Study Skills)
35 Sayre Drive; 758-3098
Edward E. Lotto, director

University Relations
436 Brodhead Ave.; 758-3171
Rita Malone, director of local media relations and internal communications
William Johnson, director of national media relations & marketing communications

Parking Services
36 University Drive; 758-3893
Patricia A. Kovacs, manager

Personnel
(See Human Resources)

University Police
36 University Drive, Room 221; 758-4200
Eugene Dax, chief

Sports Information
641 Taylor Street; 758-3174
Glenn A. Hofmann, director

University Publications/Design
30 Library Drive; 758-3015
Marvin Simmons, director of design
Suzanne Kowitz, production director
Suzanne Gaugler, business manager

Registrar
27 Memorial Drive, West; 758-3200
Bruce S. Correll, registrar

Office of Research and Sponsored Programs
526 Brodhead Ave.; 758-3021
Thomas J. Meischeid, director
Mary Jo Hill, associate director

Vice Provost for Research and Dean of Graduate Studies
5 E. Packer Avenue; 758-4210
Roy C. Herrenkohl, vice provost

Residential Services
63 University Drive; 758-3500
David M. Joseph, director

Risk Management
616 Brodhead Ave.; 758-3899
Richard Freeman, director

Student Affairs
27 Memorial Drive, West; 758-3890
Pat G. Boig, director of admissions
John W. Smeaton, assistant vice president and dean of students
Joseph D. Sterrett, assistant vice president and director of athletics

Telecommunications
30 Library Drive; 758-3008
Roy A. Gruver, director
William A. Brichta, associate director

Transportation Services
126 Goodman Drive; 758-4410
Christopher J. Christian, manager

Treasurer
27 Memorial Drive, West; 758-3180
Rhonda L. Gross, vice president for finance and administration
Richard H. Sanders, assistant vice president for financial services
Denise M. Blew, treasurer and secretary to the board

Ben Franklin Technology Center
125 Goodman Drive, Bethlehem, Pa. 18015; (610) 758-5200
Mark S. Lang, executive director

Manufacturers Resource Center
125 Goodman Dr., Bethlehem, Pa., 18015; (610) 758-5599
Edith D. Ritter, executive director
Faculty and Staff; Emeriti

The first date after the name is the date of appointment to continuous service on the Lehigh 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; CPA indicates certification as a certified public accountant. A.P.R. indicates accreditation by Public Relations Society of America. A.T.C. indicates certified athletic trainer.

A

David W. Ackland (1991), assistant research scientist, department of materials science & engineering.
Stacey M. Alderfer (1989); sr. communications analyst. B.S., Morningside, 1986.

B

Nicholas W. Balakinski (1957, 1994), professor emeritus of economics. Dipl.rer.pol., Gottingen (Germany), 1949; M.A., Rutgers, 1953; Ph.D., 1956.
Linda Bell (1981, 1990), assistant director, financial aid.
John W. Benbow (1992), assistant professor of chemistry.
B.S., Lehigh University, 1982; Ph.D., Indiana University, 1990.
Richard Benner (1986, 1994), assistant director, facilities services.
Arlan Benscoter (1987), research engineer, Energy Research Center.
Donald J. Bergeron (1978, 1994), associate director for engineering, facilities services.
Daniel Beuttenmuller (1990, 1993), asst. director, facilities services.


Shippensburg, 1976.


Linda F. Cope (1990), program administrator, office of research and sponsored programs. B.S., Juniatta College, 1984.


John N. Covert (1967), assistant director of intercollegiate athletics and recreation, varsity cross country and track coach. B.S.Ed., Buffalo State, 1953.


D


Walter E. Dahike (1964, 1985), professor emeritus of computer science and electrical engineering. Ph.D., Berlin, 1936; Ph.D., Jena (Germany), 1939.


Eugene J. Dax (1963, 1974), chief and director of campus police.


Melinda Smith de Borrero (1993), assistant professor of marketing. B.Sc., University of South Carolina, 1984; M.Sc., Virginia Polytechnic Institute and State University, 1985; Ph.D., University of South Carolina, 1993.


Margaret L. Dennis (1953, 1982), assistant librarian emerita for bibliographical services, Linderman Library. A.B., Allegheny, 1939; B.S. in L.S., Syracuse, 1940.


Adair Dingle (1989), assistant professor, electrical engineering and computer science. B.S., Duke University, 1981; M.S. Northwestern University, 1986; Ph.D., University of Texas-Dallas, 1989.


E


Andrew J. Edmiston (1967), director emeritus of counseling service and professor of education. A.B., West Virginia, 1951; B.S., Miami, 1953; Ph.D., Penn State, 1960.


Mohamed S. El-Aasser (1972, 1982), lacocca professor; chemical engineering and director, Polymer Interface Center; Center for Polymer Science and Engineering and Emulsion Polymers Institute. B.S., Alexandria (Egypt), 1962; M.S., 1966; Ph.D., McGill, 1972.


G
376 Administration, Faculty, and Staff


Patricia M. Haynes (1952, 1983), program officer, mathematics. B.S., Michigan, 1939; Ph.D., Cornell, 1943.


Elsie W. Hamel (1967, 1990), administrative associate, chemistry.


Monica Herrera (1979, 1990), software support admin., telecommunications.


James C.M. Hwang (1988), professor of electrical engineering and computer science. B.S., National Taiwan; M.S., Cornell, 1973; Ph.D., 1976.


I

B.A., Loyola Marymount, 1990; M.A., Berkeley, 1980; M.A.

Jon T. Innes (1965, 1987), professor of economics. B.S., Penn

Garth Isaac (1992), assistant professor of mathematics. B.A.,
Bethel College, 1984; Ph.D., Rutgers University, 1990.

Murray Itzkowitz (1979, 1991), professor of biology. B.S.,
Illinois, 1965; M.S., Arizona State, 1967; Ph.D., Maryland,
1970.

J

Ralph J. Jaccodine (1981, 1995), Sherman Fairchild Professor
emeritus in Solid-State. B.S., U.S. Naval Academy, 1947;
M.S., Stevens Inst. of Tech., 1951; Ph.D., Notre Dame, 1957.

James D. Jackson (1992), research scientist. B.A., University
of Maryland, 1987; M.A., University of Kansas, 1990; Ph.D.,

Thomas E. Jackson (1946, 1978), professor emeritus of
mechanical engineering and mechanics. B.S., Carnegie-

Donald Jaffe (1991), research scientist and deputy director for
Microelectronics Packaging Program. B.S., MIT, 1952; M.S.,

J. William Jahn II (1991), deputy technical director,
psychology. B.A., Grove City College, 1964; Master of
Public Administration, Auburn, 1978; Colonel, U.S.A.F. (ret.).

Himanshu Jain (1985, 1993), professor of materials science
and engineering. B.S., Kanpur (India), 1970; M.S., Banaras,
1972; M.Tech., Indian Inst. of Tech., 1974; Eng.Sc.D.,

Vaclav Janout (1990), research associate. M.S., Charles Univ.,

George R. Jenkins (1948, 1980), director emeritus, office of

John L. Jenkins (1985, 1993), professor of economics. B.S.,

Alvin S. Kanofsky (1967, 1976), professor of physics. B.A.,

Amy R. Kantra (1993), assistant director, admissions. B.A.,

John J. Karakash (1946, 1966), Distinguished Professor
Emeritus of electrical and computer engineering and dean
emeritus of the College of Engineering and Applied Sciences.
B.S., Duke, 1937; M.S., Pennsylvania, 1938; Eng.D. (Hon.),

Kazuhiko Kasai (1993), associate professor of civil
engineering. B.E., Waseda University, Tokyo, Japan, 1974;
M.Sc., University of Waterloo, Ontario, Canada, 1979; Ph.D.,
University of California, Berkeley, 1985.

Chaim D. Kaufmann (1992), assistant professor of
international relations. A.B., Princeton University, 1983;
Ph.D., Columbia University, 1990.

Eric J. Kaufmann (1986), research engineer, ATLSS. B.S.,
Lehigh, 1974; M.S., 1976; Ph.D., 1983.

B.A., Rensselaer Polytechnic, 1964; M.S., Lehigh, 1966;
Ph.D., 1968; Ph.D., 1971.

Jacob Y. Kazakia (1972, 1989), professor of engineering
mathematics. M.S., I.stanbul Tech. (Turkey), 1968; Ph.D.,
Lehigh, 1972.

B.S., Lehigh, 1948; M.A., Miami, 1955.

Jacklyn Keeley (1989), coach. B.S., Ursinus, 1984; M.Ed.,

Edwin J. Keim (1973, 1976), associate professor emeritus of
education. B.S., West Chester, 1934; M.S., Pennsylvania,
1940; Ed.D., 1951.

Karen R. Keim (1988), Lehigh Abroad Program Officer and

John L. Kemmerer (1966, 1979), purchasing agent emeritus.

Joseph P. Kender (1968, 1989), professor of education. B.A.,
Mt. St. Mary's, 1952; M.A., Villanova, 1955; Ed.D.,
Margaret A. Kercsmar (1992), program administrator, office of distance education.
Patricia A. Kovaes, manager, parking services.
Dean Krause (1975, 1982), operations supervisor, Computing Center.
Carol D. Lidie (1968, 1980), operations manager, computing center.


Ph.D., California at Berkeley, 1962.


Peter Mueller (1980), associate professor of civil engineering. Dipl. Ing., ETH (Zurich), 1967; Dr. sc. tech., 1978.


Preston Parr (1949, 1982), dean emeritus and vice president emeritus for student affairs. B.S., Lehigh, 1943; M.S., 1944.


Stephen P. Pessiki (1990), assistant professor of civil engineering. B.S., Drexel University, 1984; M.S., Cornell University, 1986; Ph.D., 1990.


Kathryn M. Richards (1989), communications specialist, development.


James J. Ricles (1992), associate professor of civil engineering. B.S., The University of Texas, 1979; M.S., 1980; Ph.D., University of California, Berkeley, 1987; P.E., California.


S


Charles B. Sclar (1968, 1990), professor emeritus of geological sciences. B.S., City College of New York, 1946; M.S., Yale, 1948; Ph.D., 1951.


Edward K. Shupp (1979, 1992), Lieutenant and associate director of campus police.


David E. Swift (1992), Captain, USA, assistant professor of military science. B.A., University of Southeastern Massachusetts, 1984.


T


Susan Terry (1985), assistant manager and textbook buyer.


Bruce Thomas (1990), assistant professor of art and architecture. B.S., University of Cincinnati, 1972; M.Arch., University of California, 1982; Ph.D., 1989.


Robert J. Trent (1993), assistant professor of management.

B.S., Michigan State University, 1980; MBA, Wayne State University, 1982; Ph.D., Michigan State University, 1993.


Donald R. Trippeer (1992), associate professor of accounting. B.S., East Carolina University, 1983; M.S., Texas Tech University, 1985; Ph.D., University of South Carolina, 1993.


W


Yi Wei (1993), visiting research scientist. B.S., Chengdu Univ. of Science and Tech., 1984; M.S., 1987; Ph.D., Univ. of Waterloo, 1993.


John W. Woltjen (1977, 1985), vice president for administration and treasurer, emeritus. B.S., Moravian, 1959.

Y

Z


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).

Bioprocessing Institute
111 Research Drive; 758-5427
Janice A. Phillips, Ph.D., director; Marvin Charles, Ph.D.; James T. Hsu, Ph.D.

Building and Architectural Technology Institute
17 Memorial Drive, East; 758-4511
David C. Amidon, Jr., M.A.; Lynn S. Beedle, Ph.D.; George C. Driscoll, Ph.D.; Francis A. Harvey, Ed.D.; Roy C. Herrenkohl, Ph.D.; Donald J. Hillman, Ph.D.; Ti Huang, Ph.D.; Celal N. Kostem, Ph.D.; Le-Wu Lu, Ph.D.; Benjamin F. Marcune; 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.

International Center for Democracy and Social Change
9 W. Packer Avenue; 758-4745
Raymond F. Wylie, Ph.D., director; Lawrence W. Beer, Ph.D.; Robin S. Dillon, Ph.D.; Kenneth L. Kraft, Ph.D.; Judith A. McDonald, Ph.D.; Rajan Menon, Ph.D.; Antonio Prieto, Ph.D.; William R. Scott, Ph.D.; Lourdes Diaz Soto, Ph.D.; Anne H. Thomas, M.A.

Center for Manufacturing Systems Engineering
200 W. Packer Avenue; 758-5157

Center for Molecular Bioscience and Biotechnology
111 Research Drive; 758-5426

Center for Polymer Science and Engineering
111 Research Drive; 758-3590

Center for Social Research
516 Broadhead Ave.; 758-3800
Diane Hyland, Ph.D., director; Donald T. Campbell, Ph.D.; Brenda P. Egolf, M.A., research scientist; John B. Gatewood, Ph.D.; Ellen C. Herrenkohl, Ph.D., research scientist; Roy C. Herrenkohl, Ph.D.; James Jackson, 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.; Melvin Thomas, Ph.D.; Lori Toedter, Ph.D., assoc. director for LVAIC Affairs; S. Lloyd Williams, Ph.D.; Elissa Wurf, Ph.D.

Chemical Process Modeling and Control Research Center
111 Research Drive; 758-4781

Diamond Center for Economic Education
621 Taylor Street; 758-3401
Anthony P. O'Brien, director

Emulsion Polymers Institute
111 Research Drive; 758-3590

Energy Research Center
117 ATLSS Drive; 758-4090
Edward K. Levy, Ph.D., director; Sunder Advani, Ph.D.; Betzalel Avitzur, Ph.D.; Katayun Barmak, Ph.D.; Russell E.
Benner, Ph.D.; Arlan O. Benscoter; Patricia Bradt, Ph.D.;
Hugo S. Caram, Ph.D.; John C. Chen, Ph.D.; Ye T. Chou,
Ph.D.; Mark A. D'Agostini, M.S.; Terry J. Delph, Ph.D.; John
N. DuPont; Thomas V. Eldredge, Ph.D.; Fazil Erdogan,
Ph.D.; Debra Eskenazi, M.S., Sharon Friedman, M.A.;
Vincent G. Guida, Ph.D.; D. G. Harlow, Ph.D.; Martin
Harmer, Ph.D.; Bruce R. Hargreaves, Ph.D.; Ronald J.
Hartranft, Ph.D.; Roy C. Herrenkohl, Ph.D.; John
Huennekens, Ph.D.; Himanshu Jain, Asst. Prof.; James T.
Hsu, Ph.D.; Stanley H. Johnson, Ph.D.; Alvin S. Kanofsky,
Ph.D.; Kamil Klier, Ph.D.; Steven Krawiec, Ph.D.; Irwin
Kugelman, Ph.D.; John Larsen, Ph.D.; Gerard P. Lennon,
Ph.D.; Le Wu Lu, Ph.D.; Arnold R. Marder, Ph.D.; John R.
McNamara, Ph.D.; Carl Moses, Ph.D.; Sudhakar Neti, Ph.D.;
Karl Norian, Ph.D.; Alexis Ostapenko, Ph.D.; Sibel Pamukcu,
Ph.D.; Alan W. Pentel, Ph.D.; Joseph N. Pflauffer, Ph.D.; Heinz
Pfeiffer, Ph.D.; Donald O. Rockwell, Ph.D.; Ursula S.
Jeffrey A. Sands, Ph.D.; Nenad Sarunac, Ph.D.; Timothy
Schmitt, M.S.; Arup Sengupta, Ph.D.; Gary W. Simmons,
Ph.D.; Dale R. Simpson, Ph.D.; Bruce M. Smackey, Ph.D.;
Fred P. Stein, Ph.D.; Harvey G. Stenger, Jr., Ph.D.; Robert D.
Stout, Ph.D.; Stephen Thode, Asst. Prof.; Jean Toulouse,
Ph.D.; Arkady Voloshin, Ph.D.; Israel Wachs, Ph.D.;
Meghanad D. Wagh, Ph.D.; Richard N. Weisman, Ph.D.;
David B. Williams, Ph.D.

Engineering Research Center for Advanced Technology for Large Structural Systems
(ATLSS)
117 ATLSS Drive, Lmbt Laboratories, Mountaintop Campus;
758-3535, Fax 758-5553
John W. Fisher, Ph.D., director; John E. Bower, Ph.D.,
deputy director; Francis A. Harvey, Ed.D., associate director-
education; John L. Wilson, Ph.D., associate director-research;
liaison and technology transfer; Bruce A. Laub, M.B.A.,
business manager; Frank E. Stokes, M.S., manager of
structural testing; Le-Wu Lu, Ph.D., connection and design
technology; Richard D. Granata, Ph.D., corrosion and sensors
technology; Richard S. Sause, Ph.D., innovative structures and
materials; Eric J. Kaufman, Ph.D., materials evaluation;
Robert J. Dexter, Ph.D., condition assessment; James M.
Ricles, Ph.D., seismic and renewal technologies.

Health Sciences Institute
111 Research Drive; 758-3645
John H. Abel, Ph.D.; Jack A. Alhadeff, Ph.D.; Barry S. Bean,
Ph.D.; Michael J. Behe, Ph.D.; Natalie Foster, Ph.D.; Ned D.
Heinzel; James Hsu, Ph.D.; Bruce M. Smackey, Ph.D.;
Michael Kuchka, Ph.D.; John G. Nyby, Ph.D.; Janice A.
Phillips, Ph.D.; Steven L. Regen, Ph.D.; James E. Roberts,
Ph.D.; Jeffrey A. Sands, Ph.D.; Keith J. Schray, Ph.D.; Neal
G. Simon, Ph.D.; Arkady Voloshin, Ph.D.; Vassie C. Ware,
Ph.D.

Iacocca Institute
111 Research Drive; 758-5452
Dr. Roger Nagel, executive director; Emory W. Zimmers, Jr.,
Ph.D., deputy director; Mr. Rusty Patterson, industry
president & CEO, The Agility Forum; Dr. Mark S. Lang,
director, Ben Franklin Technology Center; Edith D. Ritter,
director, Manufacturers Resource Center. Lehigh Faculty
Program Board: J. Richard Aronson, Ph.D.; Alden S. Bean,
Ph.D.; John W. Bonge, Ph.D.; John P. Coulter, Ph.D.; Steven
L. Goldman, Ph.D.; Mikell P. Groover, Ph.D.; Martin P.
Harmer, Ph.D.; Asha Jitendra, Ph.D.; Mark S. Lang, Ph.D.;
Carl O. Moses, Ph.D.; Manash R. Ray, Ph.D.; LeRoy J.
Tuscher, Ph.D.; Raymond F. Wylie, Ph.D. Iacocca
Professors: Mohamed El-Aasser, professor of chemical
engineering, Sharon Friedman, professor of journalism and
communications; John R. McNamara, professor economics.

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; Aurel M. Porumbescu, M.S.,
visiting research scientist.

Institute for Metal Forming
5 E. Packer Avenue; 758-4234
Betzaivel Avitzur, Ph.D., director; Ye T. Chou, Ph.D.

Institute of Fracture and Solid Mechanics
19 Memorial Drive, West; 758-4130
George C.M. Sih, Ph.D., director; Fazil Erdogan, Ph.D.;
Ronald J. Hartranft, Ph.D.; Robert A. Lucas, Ph.D.; Richard
Roberts, Ph.D.; Robert G. Sarubbi, Ph.D.; Dean P. Updike,
Ph.D.; Robert P. Wei, Ph.D.
Institute of Thermo-Fluid Engineering and Science
111 Research Drive; 758-4091
John C. Chen, Ph.D., director; Philip A. Blythe, Ph.D.; Forbes T. Brown, Ph.D.; Hugo Caram, Ph.D.; Curtis W. Clump, Ph.D.; Dennis W. Hess, Ph.D.; James T. Hsu, Ph.D.; Andrew Klein, Ph.D.; Edward K. Levy, Ph.D.; Antonios Liakopoulos, Ph.D.; Alister K. Macpherson, Ph.D.; Sudhakar Neit, Ph.D.; Jerzy A. Owezarek, Ph.D.; Donald O. Rockwell, Ph.D.; Eric Salathe, Ph.D.; William E. Schiesser, Ph.D.; Fred P. Stein, Ph.D.; Harvey G. Stenger, Ph.D.; Roger Simon, Ph.D.; Raymond Wylie, Ph.D.; Cesar A. Silebi, Ph.D.; Frank Gunter, Ph.D.; James M. Maskulka, Ph.D.; Philip A. Metzger, Ph.D.; James S. Saeger, Ph.D.; Richard W. Barsness, Ph.D., director, lacocca Institute; James W. Schmotter, Ph.D.; Mary Schranz, Ph.D., Roger Simon, Ph.D.; Raymond Wylie, Ph.D., ceramic research laboratory; Helen M. Chan, Ph.D., director, ceramics research laboratory; Y. T. Chou, Ph.D., ceramics research laboratory; John P. Coulter, Ph.D., engineering polymers laboratory; Gary G. DeLeo, Ph.D.; ceramics research laboratory; Fazil E. Erdogan, Ph.D., ceramic research laboratory; Miltiadis Hatalis, Ph.D., thin films research laboratory; Richard W. Hertzberg, Ph.D., director, mechanical behavior laboratory; Dennis Hess, Ph.D., director, thin films laboratory; Himanshu Jain, Ph.D., ceramics research laboratory; Charles E. Lyman, Ph.D., electron optical laboratory; Michael R. Notis, Ph.D., ceramics research laboratory; Sibel Pamukcu, Ph.D., environmental materials laboratory; Raymond A. Pearson, Ph.D., engineering polymers laboratory; Jeffrey Rickman, Ph.D., modeling research laboratory; Arup K. Sengupta, Ph.D., environmental materials laboratory; David Smith, Ph.D., director, electron optical 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; David B. Williams, Ph.D., electron optical laboratory.

Lawrence Henry Gipson Institute
for Eighteenth-Century Studies
9 W. Packer Avenue; 758-3367/3360
Jan Fergus, Ph.D., co-director; William G. Shade, Ph.D., co-director; Michael D. Baylor, Ph.D.; Stephen H. Cutchliffe, Ph.D.; Edward J. Gallagher, Ph.D.; Richard K. Matthews, Ph.D.; Philip A. Metzger, Ph.D.; James S. Saeger, Ph.D.; Jean R. Soderlund, Ph.D.

Philip and Muriel Berman Center for Jewish Studies
9 W. Packer Avenue; 758-4869
Laurence J. Silberstein, Ph.D., director; Robert Cohn, Ph.D., (Lafayette College); Chava Weissler, Ph.D., (Lehigh University). Associated faculty: David 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 Ill, Ph.D.

Martindale Center
for the Study of Private Enterprise
621 Taylor Street; 758-4771
J. Richard Aronson, Ph.D., director; Robert J. Thornton, Ph.D., associate director; Thomas J. Hycakl, Ph.D., associate director and director of the Kalmbach Institute for the Study of Regional Political Economy; Anthony P. O'Brien, Ph.D., head advisor to undergraduate students; Arthur E. King, Ph.D.; Richard W. Barsness, Ph.D., director, Iacocca Institute; Molinda deBorrero, Ph.D.; Colleen Callahan, Ph.D.; Parveen Gupta, Ph.D.; Frank Gunter, Ph.D.; James M. Maskulka, Ph.D.; Vincent G. Munley, Ph.D.; James Deardon, Ph.D.; Judith McDonnell, Ph.D., director, Canadian Studies Institute; James Rebele, Ph.D.; James W. Schmotter, Ph.D.; Mary Schranz, Ph.D., Roger Simon, Ph.D.; Raymond Wylie, Ph.D.

Materials Research Center
5 E. Packer Avenue; 758-3850
Martin P. Harmer, Ph.D., director; Katayun Barmak, Ph.D., thin films laboratory; Charles Booth, Ph.D., external consultant, materials liaison program; Hugo Caram, Ph.D., ceramics research laboratory; T. Brown, Ph.D.; Hugo Caram, Ph.D.; Curtis W. Clump, Ph.D.; Dennis W. Hess, Ph.D.; James T. Hsu, Ph.D.; Andrew Klein, Ph.D.; Edward K. Levy, Ph.D.; Antonios Liakopoulos, Ph.D.; Alister K. Macpherson, Ph.D.; Sudhakar Neit, Ph.D.; Jerzy A. Owezarek, Ph.D.; Donald O. Rockwell, Ph.D.; Eric Salathe, Ph.D.; William E. Schiesser, Ph.D.; Fred P. Stein, Ph.D.; Harvey G. Stenger, Ph.D.; Roger Simon, Ph.D.; Raymond Wylie, Ph.D.; Cesar A. Silebi, Ph.D.; Frank Gunter, Ph.D.; James M. Maskulka, Ph.D.; Philip A. Metzger, Ph.D.; James S. Saeger, Ph.D.; Richard W. Barsness, Ph.D., director, lacocca Institute; James W. Schmotter, Ph.D.; Mary Schranz, Ph.D., Roger Simon, Ph.D.; Raymond Wylie, Ph.D., ceramic research laboratory; Helen M. Chan, Ph.D., director, ceramics research laboratory; Y. T. Chou, Ph.D., ceramics research laboratory; John P. Coulter, Ph.D., engineering polymers laboratory; Gary G. DeLeo, Ph.D.; ceramics research laboratory; Fazil E. Erdogan, Ph.D., ceramic research laboratory; Miltiadis Hatalis, Ph.D., thin films research laboratory; Richard W. Hertzberg, Ph.D., director, mechanical behavior laboratory; Dennis Hess, Ph.D., director, thin films laboratory; Himanshu Jain, Ph.D., ceramics research laboratory; Charles E. Lyman, Ph.D., electron optical laboratory; Michael R. Notis, Ph.D., ceramics research laboratory; Sibel Pamukcu, Ph.D., environmental materials laboratory; Raymond A. Pearson, Ph.D., engineering polymers laboratory; Jeffrey Rickman, Ph.D., modeling research laboratory; Arup K. Sengupta, Ph.D., environmental materials laboratory; David Smith, Ph.D., director, electron optical 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; 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.

Musser Center for Entrepreneurship
621 Taylor Street; 758-3980
John W. Bonge, Ph.D., director; Small Business Development Center; Larry A. Strain, M.B.A., director; John E. Stevens, Ph.D., associate director; B. Kathryn Frazier, M.B.A., program director, management assistance program; Dean G. Nichols, M.B.A., program director, government marketing assistance program; Mehdi Hojjat, Ph.D., program director, international trade development program; Sandra H. Landino, M.B.A., program director, financing assistance program.

Polymer Interfaces Center
111 Research Drive; 758-3590
Rauch Center for Business Communications
621 Taylor Street; 758-4863
Peter M. Saunders, Ph.D., director.

Sherman Fairchild Center for Solid-State Studies
161 Memorial Drive, East; 758-3950, FAX 758-4561
Michael Stavola, Ph.D., director; Gary G. DeLeo, Ph.D.; W. Beall Fowler, Ph.D.; Militadis Hatalis, Ph.D.; James Hwang, Ph.D.; Ralph Jaccodine, Ph.D., Sherman Fairchild Professor of Solid State Studies; Jerome Licini, Ph.D.; Wesley R. Smith, 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)

SMART (Science Model Area Resource Team) Center
715 E. Third Street, 694-4847
Judith A. Bazier, Ed.D., assistant professor of science education and center director; David P. Krem, M.S., development coordinator; Bernice M. Gardiner, projects/educational coordinator; Susan Cummings, exhibit coordinator; Arthur Hall, exhibit technician; Marlene L.A. Gilley, volunteer coordinator; Marvin Charles, Ph.D., Professor of chemical engineering and leadership, instruction, and technology; Arnold R. Spokane, Ph.D., professor of counseling psychology, school psychology, and special education; Patricia T. Bradt, Ph.D., environmental studies.

Science, Technology and Society Program and Technology Studies Resource Center
9 W. Packer Avenue; 758-3550
Stephen H. Cutcliffe, director, Science, Technology and Society Program and Technology Studies Resource Center; Rosemarie Arbur, English; Alden S. Bean, management and marketing; Gordon Bearn, philosophy; Lynn S. Beedle, civil engineering; Gail Cooper, history; Jack A. DeBells, 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; Mikell P. Groover, industrial engineering; Robert Hanson, English; Francis A. Harvey, education; Ned D. Heindel, chemistry; Roy C. Herrenkohl, social relations; Judith N. Lasker, social relations; Benjamin Litt, management and marketing; John R. McNamara, economics; Philip A. Metzger, Linderman Library; Jeffrey Milet, 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. Pense, materials science and engineering; Tom F. Peters, art and architecture; Michael Raposa, religion studies; Richard J. Redd, art and architecture; Christine M. Roysdon, Linderman Library; Paul F. Salerni, music; William E. Schiesser, chemical engineering; George K. Shortess, psychology; 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; LeRoy J. Tuscher, education; Ricardo Viera, art and architecture; Todd Watkins, economics; Albert H. Wurth, government; Raymond F. Wylie, international relations; Ivan Zaknic, art and architecture.

Zettlemoyer Center for Surface Studies
7 Asa Drive; 758-3600
Manoj K. Chaudhury, Ph.D., associate professor of chemical engineering; Gregory S. Ferguson, Ph.D., assistant professor of chemistry; Natalie Foster, Ph.D., associate professor of chemistry; Kenneth O. Haug, assistant professor of chemistry; James C.M. Hwang, Ph.D., professor of electrical engineering and computer science; Leonard E. Klebanoff, Ph.D., associate professor of chemistry and director, surface magnetism laboratory; Kamil Klier, Ph.D., professor and chairperson chemistry and director, catalysis laboratory; John W. Larsen, Ph.D., professor of organic chemistry; Charles E. Lyman, Ph.D., professor of materials science and engineering; Fortunato J. Micale, Ph.D., professor (retired) of chemistry and director, colloid laboratory; Carl O. Moses, 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 chemical engineering and director, vibrational spectroscopy laboratory; Robert P. Wei, Ph.D., professor and chairman of mechanical engineering and mechanics and director, environment-sensitive fracture laboratory.

Research Scientists: Gim Chen, Ph.D., Ming Gao, Ph.D.; Richard D. Granata, Ph.D.; Richard G. Herman, Ph.D.; Thomas Lloyd, Ph.D.; Alfred Miller, Ph.D.; Qun Sun, Ph.D.; Kenneth T. Park, Ph.D.

Research Associates: Yeping Cai
Visiting Research Scientists: Joseph Bell, Steve Cohen, Jiri Dedecek, Goutam Deo, Kevin Kovaleski, Hwei-Min Liu, Richard MacQueen, Roy Miron, Mahmoud Moussavimadani, Jean Marc Olive, Biswanath Roy, Alex See, Chunlei Shi, Herbert Stark, Hyacinth Vedinje, Chuan-Bao Wang, Yi Wei.
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**1995-96 Academic Calendar**

**FALL 1995**

- August 23-24 (Wednesday-Thursday) - Graduate Registration
- August 25-27 (Friday-Sunday) - Freshman Orientation, Freshman Registration
- August 28 (Monday) - Undergraduate Registration
- August 29 (Tuesday) - Classes begin, last day for graduate registration

**September 1 (Friday) - Last day to file applications for Founder's Day degree**

**September 6 (Wednesday) - Last day for October doctoral candidates to deliver dissertation drafts to the dean of Graduate Studies**

**September 11 (Monday) - Last day for fall registration and adding courses; First Faculty meeting of the academic year**

**September 18 (Monday) - Last day to select or cancel pass/fail grading**

**September 23-26 (Saturday-Tuesday) - Pacing break**

**September 25-26 (Monday-Tuesday) - Rosh Hashanah**

**September 27 (Wednesday) - Monday classes meet; Last day for October master's candidates to submit unbound thesis copies to the dean of Graduate Studies**

**September 28 (Thursday) - Last day for October doctoral candidates to complete all degree requirements**

**October 2 (Monday) - Four o'clock quizzes**

**October 4 (Wednesday) - Yom Kippur**

**October 5 (Thursday) - Four o'clock quizzes**

**October 8 (Sunday) - Founder's Day**

**October 9-10 (Monday-Tuesday) - Succoth**

**October 11 (Wednesday) - Four o'clock quizzes**

**October 12 (Thursday) - Four o'clock quizzes**

**October 16 (Monday) - Midsemester reports due**

**November 6-10 (Monday-Friday) - Preregistration for Spring, 1996**

**November 8 (Wednesday) - Four o'clock quizzes**

**November 9 (Thursday) - Four o'clock quizzes; Last day for January doctoral candidates to deliver approved dissertation drafts to the Dean of Graduate Studies**

**November 14 (Tuesday) - Four o'clock quizzes**

**November 15 (Wednesday) - Four o'clock quizzes; Last day to withdraw from a course with a "W"**

**November 23-26 (Thursday-Sunday) - Thanksgiving Vacation**

**December 1 (Friday) - Last day for hourly exams; Last day to file applications for conferred January degree**

**December 7 (Thursday) - Last day for January master’s degree candidates to submit unbound thesis copies to the dean of Graduate Studies**

**December 8 (Friday) - Last day of of classes**

**December 9-10 (Saturday-Sunday) - Review-consultation-study period**

**December 11 (Monday) - Final exams begin; Last day for January doctoral degree candidates to complete all degree requirements**

**December 19 (Tuesday) - Final exams end**

**December 22 (Friday) - 8:30 a.m. Faculty grades due to Registrar’s Office**

**December 23 (Saturday) - Student grade rosters to be mailed to home address**

**SPRING 1996**

- January 11-12 (Thursday-Friday) - Graduate Registration
- January 14 (Sunday) - Commencement
- January 15 (Monday) - Undergraduate Registration
- January 16 (Tuesday) - Classes begin, last day for graduate registration

**January 29 (Monday) - Last day for spring registration and adding courses**

**February 3 (Monday) - Last day to select or cancel pass/fail grading**

**February 13 (Tuesday) - Four o'clock quizzes**

**February 14 (Wednesday) - Four o'clock quizzes**

**February 15 (Thursday) - Four o'clock quizzes**

**February 17-20 (Saturday-Tuesday) - Pacing Break**

**February 21 (Wednesday) - Classes resume, Monday classes meet**

**February 22 (Thursday) - Four o'clock quizzes**

**March 1 (Friday) - Last day for filing applications for June graduate**

**March 4 (Monday) - Midsemester reports due**

**March 9-17 (Saturday-Sunday) - Spring break**

**March 26 (Tuesday) - Four o'clock quizzes**

**March 27 (Wednesday) - Four o'clock quizzes**

**March 28 (Thursday) - Four o'clock quizzes**

**April 1 (Monday) - Four o'clock quizzes**

**April 3-7 (Wednesday-Sunday) - Easter Vacation**

**April 8 (Monday) - Classes resume; Wednesday classes meet**

**April 15 (Monday) - Last day to withdraw from a course with a "W"**

**April 15-19 (Monday-Friday) - Preregistration for Summer 1996 and Fall 1996**

**April 24 (Wednesday) - Last day for May doctoral candidates to deliver approved dissertation drafts to the dean of Graduate Studies**

**April 29 (Monday) - Last day for hourly exams**

**May 6 (Monday) - Last day of classes**

**May 7 (Tuesday) - Last day for May master’s candidates to submit unbound thesis copies to the dean of Graduate Studies**

**May 7-8 (Tuesday-Wednesday) - Review-consultation-study period**

**May 9 (Thursday) - Final exams begin**

**May 10 (Friday) - Last day for May doctoral candidates to complete all degree requirements**

**May 17 (Friday) - Final exams end**

**May 20 (Monday) - 8:30 a.m. Faculty grades due to Registrar’s Office**

**May 21 (Tuesday) - Student grade rosters to be mailed to home address**

**June 2 (Sunday) - University Day**