Lehigh

The engravings which embellish this publication are from the book *A Century After*, printed in Philadelphia in 1875, which is one of some 600,000 volumes in the university's libraries. The book, one hundred years old as this is printed in 1975, captured views of Pennsylvania as it appeared a century after the birth of the nation. The illustration on the front cover of this catalog highlights the tower of Packer Hall, the University Center, which remains a landmark on the Lehigh campus. On the back cover is a view of Mauch Chunk, Pennsylvania, where Asa Packer, founder of the university, made his home. The Delaware Water Gap, northeast of Bethlehem, is depicted on page 33.

Lehigh University was founded in 1865, a decade before *A Century After* was printed. The Caslon Old Style typeface used in major headings in this edition of *Lehigh* was popular during the latter part of the nineteenth century. A Philadelphia foundry had purchased the punches for casting the letters from the Caslon Foundry of London in 1857.

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Lehigh

This edition of *Lehigh* lists course offerings and provides other information about Lehigh University. The information contained in this edition will be revised two years hence, in 1977. Every effort has been made to insure the accuracy of all material in this edition of *Lehigh*, as of April, 1975. However, Lehigh University reserves the right to change at any time the rules governing admission, tuition, fees, courses, the granting of degrees, or any other regulations affecting its students. Such changes are to take effect whenever Lehigh University deems them necessary. This catalog has been edited and designed by the Office of University Publications, 306 Linderman Library, Lehigh University, Bethlehem, Pa. 18015. The publications staff includes George L. Beezer, director; Marvin Howard Simmons, assistant director; Curtis Bauman, production assistant, and Catherine Cruciani, secretary. Printed on web offset presses by Havertown Printing, Broomall, Pa. 45M.

I

Where to Find It

Academic Calendar

1975

April 7 (Monday)
Preregistration begins.
April 11 (Friday)
Preregistration ends.
April 18 (Friday)
Last day for June Ph.D. candidates to arrange for final examinations.
Last day for June Ph.D. candidates to deliver to Dean of Graduate School approved dissertation draft.

May 1 (Thursday)
Last day of classes for Arts seniors taking comprehensive examinations.
Last day for submission of honors theses to thesis advisors for June graduation.
May 2-7 (Friday-Wednesday)
Comprehensive examinations for Arts seniors.
May 7 (Wednesday)
Last day of classes in spring semester.
May 8 (Thursday)
Review-Consultation-Study period begins.
May 9 (Friday)
Last day for October Ph.D. candidates to arrange for final examinations.
Last day for June candidates for master's degrees to deposit with Dean of Graduate School unbound copies of theses.
Review-Consultation-Study period ends.
May 12 (Monday)
Course examinations begin.
May 16 (Friday)
Last day for June Ph.D. candidates to complete all degree requirements.
May 20 (Tuesday)
Course examinations end.

June 1 (Sunday)
University Day.

1975-76

August 25-September 2 (Monday-Tuesday)
Graduate registration for fall semester.
August 31 (Sunday)
Freshman check-in.

September 1-2 (Monday-Tuesday)
Freshman orientation.
September 3 (Wednesday)
Undergraduate registration for fall semester.
September 4 (Thursday)
Fall semester instruction begins.
September 8 (Monday)
First faculty meeting.
September 9 (Tuesday)
Last day for October doctoral candidates to deliver to Dean of Graduate School approved dissertation drafts.
September 10 (Wednesday)
Last day for filing applications for degrees to be conferred on Founder's Day.
September 17 (Wednesday)
Last day on which registration for fall courses will be permitted.
September 19 (Friday)
Last day for October candidates for master's degrees to deposit with Dean of Graduate School unbound copies of theses.
September 26 (Friday)
Last day for October doctoral candidates to complete all degree requirements.

October 6-8 (Monday-Wednesday)
Engineering inspection trips.
October 12 (Sunday)
Founder's Day.
October 27 (Monday)
Midsemester reports due.

November 3 (Monday)
Preregistration begins.
November 7 (Friday)
Preregistration ends.
November 14 (Friday)
Last day for submission of honors theses to thesis advisors for January graduation.

November 17 (Monday)
Last day for filing applications for degrees to be granted in January.
November 21 (Friday)
Last day for January doctoral candidates to deliver to Dean of Graduate School approved dissertation drafts.
November 26 (Wednesday), 10 p.m.
Thanksgiving vacation begins.

December 1 (Monday), 8:10 a.m.
Thanksgiving vacation ends.
December 8 (Monday)
Last day of classes for Arts seniors taking comprehensive examinations.
December 9 (Tuesday)
Last day for January candidates for master's degrees to deposit with the Dean of Graduate School unbound copies of theses.
December 9-12 (Tuesday-Friday)
Comprehensive examinations for Arts seniors.
December 12 (Friday)
Last day of classes.
Last day for January doctoral candidates to complete all degree requirements.
December 13-15 (Saturday-Monday)
Review-Consultation-Study period.
December 16 (Tuesday)
Course examinations begin.
December 23 (Tuesday)
Course examinations end.

January 5-19 (Monday-Monday)
Graduate registration for spring semester.
January 20 (Tuesday)
Undergraduate registration for spring semester.
January 21 (Wednesday)
Spring semester instruction begins.

February 3 (Tuesday)
Last day on which registration for spring courses is permitted.

March 13 (Saturday), 1 p.m.
Midterm vacation begins.
March 15 (Monday)
Last day for filing application for degrees in May.
Midsemester reports due.
March 22 (Monday), 8:10 a.m.
Midterm vacation ends.
March 29-April 2 (Monday-Friday)
Preregistration.

April 14 (Wednesday), 10 p.m.
Easter vacation begins.
April 16 (Friday)
Last day for May doctoral candidates to arrange for final examinations.
Last day for May doctoral candidates to deliver to Dean of Graduate School approved dissertation draft.
April 20 (Tuesday) 7:55 a.m.
Easter vacation ends.
April 30 (Friday)
Last day for submission of honors theses to thesis advisors for May graduation.

May 3 (Monday)
Last day for classes for Arts seniors taking comprehensive examinations.
May 4-7 (Tuesday-Friday)
Comprehensive examinations for Arts seniors.
May 7 (Friday)
Last day for May candidates for master's degrees to deposit with Dean of Graduate School unbound copies of theses.
Last day for October doctoral candidates to arrange for final examinations.
Last day of classes in spring semester.
May 10-11 (Monday-Tuesday)
Review-Consultation-Study period.
May 12 (Wednesday)
Course examinations begin.
May 14 (Friday)
Last day for May doctoral candidates to complete all requirements.
May 20 (Thursday)
Course examinations end.
May 30 (Sunday)
University Day.

Facts About Lehigh

History and purpose

The charter granted to Lehigh by the State of Pennsylvania states with simple directness that this university was established "for the education of youth." The institution was founded by the Honorable Asa Packer, industrialist and philanthropist, as an expression of faith in certain concepts of professional education.

Born a poor farm boy in Connecticut, in 1805, Asa Packer moved to Pennsylvania in 1822 and became one of America's pioneer captains of industry. He helped open the anthracite fields of Pennsylvania by developing a network of transportation canals and the Lehigh Valley Railroad which carried coal to market. He was elected to the state legislature, was appointed a county judge, was elected to Congress, was Pennsylvania's favorite-son candidate for president, and was a candidate for governor of Pennsylvania.

Judge Packer foresaw the great industrial development that was just beginning and which he had helped to initiate in the mineral-rich area of eastern Pennsylvania. He desired to contribute still further to the development of the region that had benefited him so much. In 1865, he asked Episcopal Bishop William Bacon Stevens to help him plan a university.

Judge Packer founded his university in the midst of educational revolution. Originally, he conceived of his institution as primarily technical. Yet, its original experimental programs were greatly modified in the fourteen years in which he guided its destiny. The general plan of study when the new institution accepted students in 1866 consisted of a two-year common core of courses for all students, with a professional elective to be chosen by the student for the final two years of study. The professional elective could be in general literature, civil engineering, mechanical engineering, metallurgy, or analytical chemistry. From the beginning, Lehigh combined the traditional American college of liberal arts, the continental university, and the new technical institute of university rank.

The coincidence of Judge Packer's concepts with those popular in his day can be seen in the fact that Lehigh was founded the same year as another important technically oriented university, Cornell, and shortly after MIT. Also, the Morrill Act, which established our land-grant colleges, was being debated when Judge Packer was a member of Congress. He fits well into the movement from the traditional liberal education of England to the more technical German programs.

Lehigh's founder was also in the avant-garde of public industrialists. During his lifetime, and by bequest, he gave Lehigh over three million dollars, including land, buildings and endowment. The generosity of the Packer family and friends, the distinguished faculty originally assembled, and the prominence of early alumni firmly established the reputation of Lehigh in higher education.

Lehigh University is fully accredited by the Middle States Association of Colleges and Secondary Schools. In addition, specialized programs in business administration are accredited by the American Assembly of Collegiate Schools of Business, the engineering curricula are accredited by the Engineers Council for Professional Development, and Council for Professional Development, and various School of Education programs are accredited by the National Council for Accreditation of Teacher Education, including Commonwealth of Pennsylvania approval for certification programs.

The current market value of the endowment fund of the University exceeds forty-one million dollars. The value of equipment, buildings, and grounds is nearly seventy-five million dollars.

Organized as a small university

When Lehigh opened its doors in 1866, it was given the character of a small university. Today, the undergraduate enrollment is 3,950; the graduate enrollment 2,150. Lehigh desires to remain a small university, and with its faculty of more than 400, to provide the best possible education for a coeducational student body of its size.

Lehigh is primarily a residential university. Seventy-six percent of the undergraduate students live in university-operated residence halls on the campus or in the houses of national social fraternities which maintain chapters at Lehigh. The remainder of the students are either from the community and live at home, or are from distant points but elect to main-

tain their own rooms or apartments in Bethlehem.

Current undergraduates come from about 1,000 public and private secondary schools in 40 states and 31 foreign countries.

Thirty-nine percent of the undergraduates are enrolled in the College of Engineering and Physical Sciences; thirty-five percent in the College of Arts and Science; and twenty-four percent in the College of Business and Economics. The remaining two percent are enrolled in the five-year arts-engineering sequence or in the General College Division.

Lehigh continues to base its program on the premise that an education for successful living must combine the acquisition of knowledge and skills fundamental in the professions with courses designed to broaden the vision and to enrich the personal life of the individual. Therefore at Lehigh requirements for graduation include studies preparatory to a career, a generous number of courses to acquaint the student with the nature and problems of the world in which he or she lives, and opportunities to develop himself or herself as an individual.

Campus and community

Located on a 200-acre hillside campus on the south side of the Lehigh River, the towers of Lehigh University overlook the City of Bethlehem, which has a population of 73,000, and is located in eastern Pennsylvania, approximately 60 miles north of Philadelphia and 90 miles west of New York City.

In founding his university, Judge Packer provided the site for the campus "in the midst of a noble park of forest trees." A century later, there remains abundant evidence of the source of Judge Packer's inspiration, for the trees continue to preserve the quiet campus atmosphere. Most of the University's buildings are located on the north slope of South Mountain. The Saucon Valley campus, located about a mile south of the main campus, comprises some 600 acres. A number of playing fields and athletic facilities are located on the Saucon Valley campus, and the area is being developed into a major sports complex to serve the university.

Settled in 1741 by Moravians seeking religious asylum, Bethlehem is rich in historic tradition. The city became an important point for early colonial travelers stopping between New York and Philadelphia. Twenty-one remarkably preserved pre-Revolutionary War buildings remain in the heart of the city. Many have been restored and others will be reconstructed. Each spring, the city and the campus receive thousands of music lovers who come to hear the Bach Festival in Lehigh's Packer Memorial Church. The City of Bethlehem is a center of industry and education. Bethlehem Steel Corporation maintains its principal administrative offices in the community, as well as research laboratories and a major production facility. Lehigh University, with nearly 1,500 employees, is the city's second-largest employer.

There are five colleges in the Lehigh Valley besides Lehigh, all private. They are Lafayette, Allentown College of St. Francis de Sales, Moravian, Muhlenberg, and Cedar Crest. A cooperative program is maintained among the colleges. There are also two two-year community colleges in the area.

Undergraduate Admission

Requirements

The enrollment of Lehigh University is strictly limited by action of its board of trustees, with a resulting limitation in the number of candidates who can be admitted each year to the several divisions of the University. The University is independent, nondenominational and coeducational, and accordingly seeks candidates without regard to race, color, sex, religious creed, or national origin.

In the selective procedure necessitated by enrollment limitation, the University, through its Office of Admission, takes into account a number of criteria which are believed to have some individual validity and in combination a high degree of validity in predicting probable success in college work.

Secondary school preparation

The admission policy of the University is designed to encourage students with varied backgrounds to consider Lehigh while insuring that any individual student is not guided into a program of studies for which he or she is inadequately prepared.

The courses or units required for admission represent the quantitative equivalent of the usual four-year college preparatory program and include certain prescribed subjects for candidates depending upon their college and curriculum choice.

An applicant's full potential as a Lehigh student, including evidence of academic growth and the desire to learn, are special qualities which may not be reflected in mere accumulation of units.

All applicants should have completed four years of English, two to four years of history and social studies, three years of mathematics and two to four years of laboratory science. (Chemistry is required and physics recommended for candidates planning studies in science or engineering.)

Students planning to enter the College of Engineering and Physical Sciences or the College of Business and Economics, or the bachelor of science program in the College of Arts and Science, must have studied mathematics through trigonometry.

Students planning a bachelor of arts degree in the College of Arts and Science must present at least two years of one foreign language. However, foreign language study is not mandatory at Lehigh.

One of the major features of Lehigh is the ease with which a student may normally transfer from one curriculum or college to another. Such transferring may, however, necessitate a student's obtaining additional background for the new discipline area on campus or elsewhere.

Summary of minimum subject matter requirements (16 units)

English 4
Foreign Language* 2
College Preparatory Mathematics** 4
Electives 6

*Waivers of the requirement in foreign language are granted to otherwise well-qualified candidates for admission to all three of Lehigh's 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, fine arts, classics, drama, English, modern foreign languages, government, history, international relations, journalism, music, philosophy, religion studies, social relations, and urban studies.

Note: Chemistry is required and physics is recommended for candidates planning programs in science, arts-engineering, and engineering. Electives should include such college preparatory subjects as languages, social studies, and sciences.

Quality of Work

The quality of the candidate's work is more important than merely meeting minimum subject matter requirements. The strength of his or her preparation is judged primarily by the individual's rank or relative grade in class; by the extent to which he or she has made grades distinctly higher than the average grade; by evidence of improvement or deterioration in quality of record as he or she progressed through secondary school; by relative success or failure in the particular subjects which the student proposes to continue in college; and by the comments and recommendations of the principal or headmaster.

Entrance examinations

All candidates for admission to the freshman class are required to write entrance tests prepared and administered by the College Entrance Examination Board. Tests required by Lehigh University are listed below.

Scholastic Aptitude Test

Each candidate is required to write the Scholastic Aptitude Test (SAT) to provide the University with a measure, on a national scale, of his or her aptitude and readiness for college study. The University prefers that this test be written early in the senior year, unless satisfactory junior year scores were submitted to Lehigh.

Achievement Tests

Each candidate is required to write *three* additional College Board Achievement Tests. One of these must be English Composition. Candidates for a science program in the College of Arts and Science or for a program in the College of Engineering and Physical Sciences are expected to write a Mathematics (Level I or Level II) Achievement Test. Candidates for Engineering and Physical Sciences are expected to write a Science (chemistry or physics) Achievement Test. Candidates for B.A. programs in Arts and Science, *including* five-year Arts-Engineering candidates, should write an Achievement Test in the foreign language (if any) to be studied in college. Other candidates write tests which they may choose in consultation with their advisors. The English Composition and two additional Achievement Tests should be written in the senior year, unless satisfactory junior year scores were submitted to Lehigh University.

Test information and applications should be secured from the College Entrance Examination Board at either of the following addresses (whichever is closer to the candidate's home or school): P.O. Box 592, Princeton, New Jersey 08540 or P.O. Box 1025, Berkeley, California 94701, or from the candidate's school.

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 the candidates who will be tested in Europe, Asia, Africa, Central and South America, and Australia).

The candidate is responsible for requesting that the test score be sent to Lehigh—either by indicating Lehigh on the College Board application or, if he or she failed to do this, by special request to the College Board office. In addition to requesting that the College Board scores be sent to Lehigh, the candidate must submit an application for admission to the freshman class at Lehigh.

Other criteria and interviews

Information about other qualifications of candidates is obtained from principals, headmasters, and counselors. Such information relates to the candidate's health, emotional stability, intellectual motivation, social adjustment, participation in school activities, and established habits of industry and dependability.

Each candidate is urged to visit Lehigh whenever possible so that he or she may see the University and talk with an officer of admission. An appointment should be made in advance of the visit.

The Office of Admission is open for interviews every weekday between 9 and 11 a.m. and from 1:30 to 4 p.m. Tours of the campus are available every weekday afternoon, at which time classes are in session. Special arrangements may be made for Saturday morning interviews and tours. The Office of Admission is closed Sundays, national holidays, Saturday afternoon during the school year, and all day Saturday during the summer months. Visitors are welcome during the summer months.

Although a personal interview is not required of all candidates, the University reserves the right to require an interview whenever this appears desirable or necessary and to base determination of admission in part on the report of the interviewing officer.

Procedures

Admission to the freshman class

If a candidate has determined that he or she is sincerely interested in Lehigh and if the student believes that he or she will meet admission requirements of subject matter and school record, the individual should secure from the Office of Admission an application for the freshman class entering in September. (Lehigh does not admit a freshman class in February.)

The application should be submitted early in the last year of preparation for college. Every effort should be made to submit an application during the

fall semester of the senior year and definitely not later than March 1.

Application Fee

Each undergraduate application for admission to the freshman class or with advanced standing or to the General College Division must be accompanied by an application fee of $15. The check or money order should be made payable to Lehigh University. The application fee is non-refundable in the event the candidate does not matriculate at Lehigh University. It is not applied toward tuition if the candidate matriculates. An application cannot be accepted without the fee.

Early Decision

Lehigh will give a candidate an early favorable decision on his or her application if the individual meets the following criteria: (1) Preliminary credentials, including Scholastic Aptitude Test scores, show clear qualification for admission to Lehigh; (2) The person is certain that Lehigh is his or her first choice of college.

On this basis the Committee on Admission selects candidates who have submitted requests for early decision by November 1. Lehigh's decisions will be made by December 1. If the decision is favorable, it is assumed the candidate's academic strengths will continue throughout the senior year and that he or she will complete all normal admission requirements. On receiving a favorable decision, the candidate promptly withdraws other applications.

Early Decision candidates whose parents have submitted Parents' Confidential Statements will receive notice by December 1 of the action taken on requests for financial aid.

This plan is not appropriate for all of our candidates. There are many candidates who are unable to make an early college choice. Such candidates are not penalized. Candidates who do not receive favorable replies to their requests for "early decision" should not feel discouraged. Only a portion of the class is selected under this plan, since the Committee on Admission still prefers to take action on most applications later in the year.

Advanced Placement

There are several means whereby able students with superior preparation may obtain advanced placement and/or college credit at Lehigh.

In many secondary schools able and well-qualified students have opportunities to enroll in one or more Advanced Placement courses given under the auspices of the College Entrance Examination Board (CEEB). Lehigh encourages students to enroll in these college-level courses and to write the Advanced Placement tests offered by the CEEB each May. Entering freshmen who ask the CEEB to submit their test scores and papers to Lehigh, and who are recommended by their schools, are considered for advanced placement and/or college credit.

Advanced Placement test scores range from a low of 1 to a high of 5. Students who earn the recommendations of their schools and scores of 3 or higher on the Advanced Placement tests receive advanced placement and/or credit in most departments. A few departments regularly offer special examinations during Freshman Orientation to students who completed college-level courses in secondary school, who did not write Advanced Placement examinations, and who request permission to write the tests. The current practices at Lehigh follow:

Biology. Advanced Placement and three semester hours of Lehigh credit for Biology 21 to students who earn scores of 3 or higher. Students may obtain an additional hour of credit for Biology 22 after consultation with the chairman of the department during Freshman Orientation.

Chemistry. Advanced Placement and five semester hours of Lehigh credit for Chemistry 21 and Chemistry 22 to students who earn scores of 4 or 5. Other students who earn scores of 750 or higher on the Chemistry Achievement Test of the CEEB receive equal credit. The department administers tests during Freshman Orientation to students who did not write the Advanced Placement examination and who wish to establish credit for the first Lehigh course.

English. Advanced Placement and six semester hours of Lehigh credit for English 1 and 2, 10, 14 or 16 (the standard freshman courses) to students who earn scores of 3 or higher on the CEEB Advanced Placement Test in English. Other students who earn a score of 700 or higher on the SAT-Verbal Aptitude Test receive equal credit.

History. Advanced Placement and credit to students

who earn scores of 4 or 5 on the American History or European History examinations. Consideration for advanced placement and/or credit to students who earn scores of 3. Special courses, History 51 and History 52, are available to students who earn Advanced Placement and/or credit.

Latin. Students receive three semester hours of credit for a score of 3 or higher on the Vergil exam; those who write exams in more that one area (e.g., Vergil and lyric poetry) receive six semester hours of credit.

Mathematics. Advanced Placement and four semester hours of Lehigh credit for Mathematics 21, Analytic Geometry and Calculus I, to students who earn scores of 3 or higher on the Calculus AB examination; advanced placement and eight semester hours of Lehigh credit for Mathematics 21 and Mathematics 22, Analytic Geometry and Calculus I and II, to students who earn scores of 3 or higher on the Calculus BC examination. Other students, selected by the department of mathematics on the basis of entrance credentials, are invited to participate in an accelerated calculus sequence, Mathematics 31 and 32. Upon completion of Math. 31 and 32, each of which carries four credit hours, and upon certification of superior performance by the department of mathematics, the student receives four hours of advanced placement credit in calculus. The department also administers placement tests in any of its courses during Freshman Orientation to students who request permission to write a test.

Modern Foreign Language. Advanced Placement and three semester hours of credit to students who earn scores of 4 on an Advanced Placement Test. Advanced placement and six hours credit to students who earn scores of 5 on an Advanced Placement Test. Three semester hours of credit are granted to students who earn scores between 670 and 740 on a CEEB modern language achievement test. Those students who earn scores of 750 or higher receive six semester hours of credit.

Music. Advanced Placement and three semester hours of credit to students who earn scores of three or higher.

Physics. Advanced Placement and five semester hours of credit for Physics 11 and 12, Introductory Physics I, to students who earn scores of 4 or 5 on the Physics C examination or who earn scores of 5 on the Physics B examination. The department also administers placement tests to students who request permission to write a test.

International Baccalaureate. Students who write the International Baccalaureate are granted credit in those higher-level subjects in which they earn scores of 4 or higher.

The University encourages the initiative which secondary school students are showing in enrolling in advanced courses, in requesting advanced standing in college, and in assuming responsibility for a greater share of their own education. Besides opportunities for advanced placement of freshmen, sophomores are invited to consider the advantages of enrolling in some junior courses. This may be accomplished by special examinations available in certain courses for students who performed particularly well as freshmen.

In the junior year students may register for interdepartmental honors seminars and in some programs may take what is referred to as "unscheduled work," where they have an opportunity to do individual work in consultation with a member of the faculty. In the senior year students may continue with the interdepartmental honors seminars and may undertake departmental honors programs. Particularly well-qualified students are permitted to take a limited number of graduate courses. Some students engage in research projects in connection with their senior thesis.

The opportunities for able and well-motivated students are increasing each year and more students are qualifying each year for advanced sections and courses and honors programs.

Acceptance of admission and deposit

Selection of candidates for the freshman class entering in September is made between the end of February and April 1 following receipt of College Board scores and preliminary secondary school records. Lehigh subscribes to the "Candidates' Reply Date," which has been set at May 1.

When a candidate's preliminary credentials are complete and the person has been offered formal admission to Lehigh University, he or she will be asked to notify the Director of Admission of acceptance of the offer of admission by making a deposit of $50 to hold the place for the student in the limited enrollment. This deposit is not an additional fee but is applied toward tuition charges for the first semester. However, the deposit is forfeited in case of failure to enroll for the specified semester.

Transfer Students

Candidates for admission from other institutions are admitted with advanced standing to the three colleges of the University. Such candidates must have met the subject matter entrance requirements prescribed for undergraduates at Lehigh. No entrance examinations are required.

A candidate who has studied at another college prior to applying for admission to Lehigh will be considered on the basis of the quality of his record at that college. A candidate who has been dropped from another college for disciplinary reasons or for poor scholarship or who is not in good standing at the former college is not eligible for admission to Lehigh.

A student who is planning to transfer to Lehigh University should so arrange his or her work in college that he or she will cover as many as possible of the subjects of the chosen curriculum at Lehigh.

A student who desires to transfer to Lehigh University from another college must submit an application for admission (on a special transfer form) with the $15 application fee. He or she must request each college previously attended to submit to the Office of Admission at Lehigh University an official transcript of his or her academic record. Catalog pages describing the courses completed at other colleges should be enclosed with the application. It is not necessary to send complete catalogs.

A candidate who has attended more than one university, college, or junior college must present a record from each institution. Failure to submit a complete record of former academic experience will result in cancellation of admission or registration.

Costs and Accommodations

Undergraduate expenses

Tuition in Lehigh's undergraduate colleges is $3,300 a year for 1975-76. An increase for 1976-77 is projected but the amount is not known at this writing. A student regularly enrolled in any of the undergraduate divisions of the University who registers for fewer than the normal hours of work will pay either $138 for each semester-hour carried, or the regular tuition, whichever amount is lower. Lehigh University reserves the right to change at any time the rules governing tuition and fees.

Items of personal expense are dependent upon each student's personal habits and circumstances. There are certain basic expenses in addition to tuition which must be met. For example, books, stationery, and drawing instruments may be purchased at the bookstore in Maginnes Hall at an average annual expense of about $175. This allowance does not include personal expenditures.

Since Lehigh is primarily a residential university, provision is made for student living quarters and dining facilities, and social fraternities. Not all upperclassmen live in residence halls or fraternity houses. A few elect to live in off-campus apartments or rooming houses. Students living in residence halls are required to eat in the University dining facilities. Four basic meal plans are available, and are described later in this section. There are no fees for athletics, health service, library, student activities, or student concerts and lectures. In addition, there are no matriculation, graduation, or laboratory fees.

Undergraduate fees are payable prior to registration. A bill will be rendered by the Bursar's Office which will indicate the payment date. If desired, payment may be made in installments of 60 percent, plus a service charge of $3 per semester, due prior to registration, 20 percent due one month after registration, and 20 percent due two months after registration. The $3 service charge is not refundable.

Residence halls

More than half of Lehigh undergraduates live in University residence halls. Lehigh has eight principal residence halls for undergraduate men and women. Most rooms are designed for two students, but a limited number of single, triple, suite arrangement, and apartment units are available.

Residence units include the following: Dravo, Drinker and Richards houses, comprising the so-called "freshman quadrangle"; McClintic-Marshall House; Taylor House; the Centennial I and Centennial II complexes; the Residence Halls 11 complex (student apartments), opening during 1975; Bishopthorpe Residence; and the Saucon Married and Graduate Students apartment complex on the Saucon Valley campus, which was completed in 1974.

Room rental charges in the residence halls range from $290 to $387.50 per semester in 1975-76. An additional charge of $45 to $52.50 per semester is made for single rooms. Maid service except for apartment units is included in the room fee, and all essential furniture is provided. Rooms are rented on an annual lease basis only.

When a candidate accepts an offer of admission to the freshman class, the candidate is sent a Room and Board Application-Contract. Those desiring accommodations in the residence halls are urged to return this application-contract promptly because priority of assignment is based on date of receipt of this application, acceptance of admission, and application for admission. A non-refundable advance deposit of $100 must accompany the application. The deposit will be credited to the fall semester room and board charges. Normally freshman room assignments are made in early August by the residence halls office.

Freshmen who wish to room together must make special request with their applications, and letters from parents or guardians of each student should be submitted in support of the request. Any questions concerning residence halls should be directed to the residence halls office.

Students desiring to continue in the residence halls as upperclassmen are permitted to file application-contracts in early spring. Based on priorities and availability, contracts are accepted April 1 for the following academic year. A $100 advance deposit is required.

Each student in the residence halls is provided with a bed, mattress, chest of drawers, and chairs. Residents supply such personal items as pillows, waste-paper baskets, quilts, ashtrays, and radios. Most residents must supply their own desk lamp. Students may supply their own bed linen and towels and make their own arrangements to have these laundered, or they may subscribe to a linen service which provides clean bed linen and towels each week. The present charge for this service is approximately $35 for the school year.

Personal laundry is handled by the student on an individual basis. A laundry service is made available in the residence halls by a local firm at approximately $95 per year. Other students use coin-operated washers.

Residents are held responsible for any damage done to their rooms or any other part of the residence halls and their equipment.

The University is not responsible for the loss or destruction of any student property whether such losses occur in the residence halls, lockers, classrooms, etc. The safekeeping of student property is the responsibility of each individual student and no reimbursement from the University can be expected for the loss of such property. Insurance protection, if desired, may be obtained by a student or his parents from an insurance broker or agent.

Information on off-campus housing may be secured from the residence halls office.

Social fraternities

Approximately one-third of the male students live in fraternity houses. Such accommodations are available to upperclassmen who receive invitations to join the groups.

Of the thirty-one social fraternities with chapters at Lehigh, twenty-seven occupy houses on the campus. The remaining houses are in Bethlehem adjacent to the campus. Freshmen are "rushed" during the first semester of the freshman year, but they usually do not move into fraternity houses until the sophomore year. Many commodities and services needed by the fraternities are provided by the cooperative Fraternity Management Association. Students who accept invitations to live in fraternities are required to formalize their acceptance in a written contract with the fraternity. These contracts are based on budgets prepared with the Fraternity Management Association and approved by the fraternity chapters and alumni corporations. These contracts are binding in

the fraternity segment of the University's residential system. Accordingly, upon registration for the academic period covered by contract, fraternity members are obligated to pay approved fraternity bills through the University.

Living costs in fraternities vary with the individual chapters but are generally of the same order of expense as residence (room and board) in University-operated halls.

All of the fraternities are nationally affiliated. The chapters include the following: 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, Tau Epsilon Phi, Theta Chi, Theta Delta Chi, Theta Xi and Zeta Psi. Locations of these houses may be found on the map at the back of this catalog.

Dining services

Each student who lives in the residence halls is provided with board in the University dining services. The four board plans available for 1975-76 include the following:

Plan A. Twenty-one meals per week at $390 per semester. This includes three meals daily beginning with the evening meal before the first day of classes and continuing, except for announced holidays, through the noon meal of the last day of the examination period each semester.

Plan B. Seventeen meals per week at $357.50 per semester. This includes Monday breakfast through and including Saturday lunch, beginning with the evening meal before the first day of classes and continuing, except for announced holidays, through the noon meal of the last day of the examination period each semester.

Plan C. Fifteen meals per week at $345 per semester. This includes Monday breakfast through Friday dinner beginning with the evening meal before the first day of classes and continuing, except for announced holidays, through the noon meal of the last day of the examination period each semester.

Plan D. Ten meals per week at $330 per semester. This includes lunch and dinner Monday through Friday beginning with the evening meal before the first day of classes and continuing, except for announced holidays, through the noon meal of the last day of the examination period each semester.

Plan A is required for freshmen residing on the campus. Upperclassmen residing on the campus have the choice of any of the four plans.

The board plans and the student dining rooms are open primarily to students of the residence halls. These plans may be extended to students who do not live in residence halls on a limited basis. In addition, a five-lunch-per-week plan is available (the noon meal, Monday through Friday) at a cost of $120 per semester, and a five-dinner-per-week plan is available (the evening meal, Monday through Friday) at a cost of $215 per semester. Students who do not live in the residence halls may apply to the Bursar for participation in one of the dining plans.

Freshmen residing on the campus are required to eat their meals in the University dining facilities during Freshman Orientation. There will be an additional charge for serving the three meals per day during Freshman Orientation.

Each student who participates in one of the board plans will receive a dining service identification card which is not transferable. Use of the card by someone other than to whom it is issued is not permitted and will result in disciplinary action. New cards will be issued to replace lost cards upon the payment of a fee of $10.

Visitors on campus may eat in the Asa Packer Room, the faculty and guest dining room located on the third floor of the University Center. A snack bar in the University Center is open to all students and visitors.

Special fees

Military and band deposits. A deposit of $25 is made by each student enrolling in military science, aerospace studies or in band. This deposit is refunded when the property issued to the student is returned.

Chemistry breakage. Students taking chemistry laboratory courses are required to reimburse the University for returnable equipment broken or otherwise damaged and for all chemicals used in excess of reasonable amounts.

Examination fees. Students who for satisfactory reasons absent themselves from final examinations will be allowed, upon petition, to take make-up examinations without payment of an examination fee. A fee

of $5 is charged for any examination subsequent to the first regular final or make-up examination allowed upon petition in any course. This regulation applies to the psychological and placement examinations required of new students if taken at some time other than those scheduled.

Late registration fees. The cost of procuring a registration ticket after the time specified by the Registrar is $10. A student who does not complete registration within three days after the date of the registration ticket is subject to a penalty of $10. No registration will be accepted later than the tenth day of instruction in a regular semester or the fifth day of instruction in any summer term.

Late preregistration fee. The penalty for a late preregistration or a change in preregistration is $10. This will be waived for cause upon the recommendation of the college dean.

Change-of-roster fee. Having once registered in any semester, a student may not drop any course except on the recommendation of the director of his or her curriculum. There will be a $10 change-of-roster fee for each change unless it is waived by the college dean.

Late installment payment. In certain cases, students are permitted to pay semester bills in three payments. In other cases, emergency short-term loans are granted to be repaid in period installments within the semester in which the loan is granted. A penalty fee of $10 is levied on any student who fails to make payment in accordance with the agreed schedule.

Late payment of fees. University fees are payable prior to registration. If payment, or provision for payment satisfactory to the University, is not made prior to registration, a fee of $10 will be assessed if such payments, or provisions for payments, are made after the registration date.

Late application for degree fee. A fee of $10 is charged for late filing. See Notice of Candidacy for Degree for dates.

Application for admission fee. A fee of $15 is required with each application for admission to the undergraduate colleges of the University.

Listener's fee. Undergraduate students enrolled in less than a full program who wish to attend a course or courses without obtaining credit will be charged a listener's fee equivalent to the tuition cost of one credit hour for each such course attended.

Transcripts. Each student is entitled to one copy of his or her record free of charge. This can be an official or unofficial transcript. Unofficial copies are released to the student; official copies are sent directly to the educational institution, company, state board, etc., as the circumstances may require. After the first copy is released a fee of $1 is assessed for each subsequent copy.

Refunds

Tuition. In the event of the death of a student or his or her involuntary induction into the armed forces, tuition will be refunded in proportion to the fraction of the semester remaining at the time the student leaves.

If a student withdraws from the University, he or she is entitled to receive a refund of tuition less $100 and less a deduction of 2 percent of the tuition for each day of instruction completed, computed from the first day of instruction in the semester. No student who is suspended or expelled from the University shall be entitled to any refund.

A summer session student who formally withdraws from the University is entitled to receive a refund of total tuition less $5 for each credit hour for which the student is registered and less a deduction for each day of regular instruction of 4 percent of the total tuition paid computed from the first day of instruction in the session.

Refunds will be made through the tenth day of instruction in a regular semester to undergraduate students for reductions of schedules below twelve credit hours (full time). The refund shall be in an amount equal to the number of credit hours remaining multiplied by the credit hour rate deducted from the semester tuition paid. Refunds will be made through the fifth day of instruction in the summer session for reductions of schedules in an amount equal to the credit hours dropped multiplied by the credit hour rate. No refunds will be made to any undergraduate student for any reduction in schedule after the tenth day of instruction in a regular semester or the fifth day of instruction in a summer session.

Residence hall rental and dining service charge. Residence hall rooms are rented on an annual lease basis only. A student who signs a Room and Board Application-Contract is expected to occupy a room in the residence halls for the full college year.

An advance deposit on residence hall rental and

dining service charges of $100 will be required with the signing of the contract. The deposit will be credited to the fall semester room and board charges.

A full refund of all residence hall rental and dining service charges paid, including advance deposits, will be made in the event a student does not register because of illness, injury, death, induction into the armed forces, or if the student is dropped from the University for academic reasons. In such cases the University must be notified within ten days to be eligible for refund. Should the student be readmitted to the University for the following fall or spring semester and there are accommodations available in the residence halls system at the time of readmission, the student is bound by the contract to accept residence halls accommodations. Except for the reasons stated above, no refund will be granted to incoming freshmen.

No student who is suspended or expelled from the University for disciplinary reasons shall be entitled to any refund of deposit or residence hall room and dining service charges.

Currently enrolled students who sign Room and Board Application-Contracts in the spring for residence as upperclassmen in the following year are entitled to a partial refund of advance deposit if the following requirements are satisfied:

A. In the event of voluntary withdrawal from the University.

B. In the event of desired voluntary withdrawal from the residence halls if the lease can be transferred to another student for whom no other accommodations exist. If the lease cannot be transferred to another student, for whom there are no other accommodations, there will be no refund of deposit and the student will be held liable for the full amount of the residence halls and dining service charges contracted.

C. Partial refund schedule:

Notification received by the University on or before	Amount of Refund
May 1	$60
July 1	$40
August 15	$20
After August 15	no refund

A refund of residence halls rentals and dining service charges will be made on a proportionate basis after registration in the event of a student's involuntary withdrawal from the University due to illness, injury, death, or induction into the armed forces. In the event of voluntary withdrawal from the University no refund will be made except in the case of a transfer of lease to another student for whom no other accommodations exist. In the event of a transfer of lease to another student under these conditions, a proportionate refund of residence hall rental and dining service charges less $50 will be made. The maximum proportionate refund cannot exceed the total of residence hall rental and dining charges less $100.

No residence hall or dining service refund will be considered until (and date for calculation of proportionate refund will be determined by) such date that room is vacated and door key(s) and dining service meal ticket are returned to the residence halls office.

A student who forfeits a room and dining service reservation in the fall semester and who returns to the University in the spring semester is still obligated for room rental and dining service charges for the spring semester providing such facilities are available.

A refund shall be certified to the Bursar by the residence halls office.

Payment. All refunds, including overpayments of charges resulting from scholarship awards, loans, financing arrangements with banks, etc., will be made by check payable to the student. A minimum of ten days is normally required to process refund checks.

Financial Assistance

Lehigh extends grant and self-help opportunities to deserving and promising students who would not otherwise be able to attend the University, to the extent that funds are available for such assistance. Approximately twenty-six percent of the present undergraduate enrollment has received University assistance. In addition, outside grants and loans were awarded to Lehigh students from programs sponsored by the Commonwealth of Pennsylvania, military science and aerospace studies programs, and many private and state-sponsored organizations.

How to apply for aid

To be equitable in the awarding of financial assistance, "need" must first be clearly evidenced. Families are required to file the Parents' Confidential Statement with the College Scholarship Service, and all applicants, whether they are entering freshmen or upperclass renewals, are required to submit directly to the Office of Financial Aid a notorized copy of their parents' 1040 income tax return statement. Once need has been established, the Committee on Undergraduate Financial Aid endeavors to aid as many well-qualified applicants as funds will allow. An increasing number of students have been aided since the advent of the "package" concept of awards, whereby a student receives a combination of grant assistance and self-help (loan and campus employment). Self-help allows the student a greater degree of personal involvement in the financing of his or her own education.

In the competition for financial aid funds, emphasis is placed upon exceptional academic achievement and promise, commendable participation in activities outside the classroom, and good citizenship. Awards are made on a yearly basis. For an award to be renewed, an updated Parents' Confidential Statement is required to establish continued evidence of need and the level of assistance indicated. Continuation of an award assumes that the recipient will continue to show scholastic excellence and leadership activity commensurate with the promise shown when the award was originally made.

Eligibility for funds

A special scholarship application is not required by Lehigh. Requests should not be made for a particular type of scholarship. The submission of a College Scholarship Service form before January 15 establishes the candidate as an applicant for all types of financial aid for which he or she is eligible.

The Committee on Financial Aid makes first selections in March and notifies all candidates promptly.

All upperclassmen applying for financial aid consideration may obtain their applications from the Office of Financial Aid at the beginning of the spring semester. The Committee on Financial Aid reviews upperclass applications within three weeks of receiving grades for the spring semester, and notifies applicants as promptly as possible.

Transfer applicants for aid consideration are reviewed with the freshman group, provided that the admission and financial aid dossier is complete.

Sources of assistance

Trustee scholarships. These are awards covering the tuition charges in whole or part, provided by allocation of the Board of Trustees from general funds in order to supplement endowed scholarships.

Endowed and supported scholarships. These are provided by individuals and by corporations either through endowments or by annual contributions, and are granted to able and deserving students who otherwise would not be able to attend college.

Leadership awards. While still requiring evidence of genuine financial need, good scholarship, and good citizenship, these awards place more emphasis on leadership attainments in non-academic activities. These include Alumni Student Grants provided for good students with both aptitude and achievement in athletics. Leadership awards are restricted in terms of the particular qualifications and interests of the applicants as indicated in each instance.

Lehigh University Merit Scholarships. These are granted in cooperation with the National Merit Scholarship Corporation. The corporation and Lehigh annually award up to twenty four-year Merit Scholarships financed through the University's Annual Fund. The National Merit Scholarship Corporation conducts the competition for these scholarships as well as all others under its supervision. Final selection of Lehigh University Merit Scholars is limited to Merit Finalists

who wish to attend Lehigh University and are qualified to do so. The individual stipend is based on the candidate's need as estimated by the University and is adjusted annually according to the financial status of his or her parents and the student's ability to earn funds during vacation periods. Stipends range from $100 to $1,500 per year.

Tuition loans. Such loans are made on the basis of merit and need, at the discretion of the Committee on Undergraduate Financial Aid to the extent that funds are available. No loan can be made to a student on scholastic or disciplinary probation except with the unanimous consent of the Committee. The maximum indebtedness to the University that any student may normally incur will generally not exceed one-half of total tuition obligations up to and including the semester for which he or she is seeking tuition aid.

Each student qualifying for a tuition loan is asked to sign a note, *endorsed by his or her parents or guardian.* A repayment schedule satisfactory to the University may be arranged through the Office of Financial Aid.

Short-term loans. These are emergency loans and must be repaid, according to an acknowledged schedule, before the end of classes of the semester for which they are granted. Short-term loans bear interest from the date of the note. A minimum interest charge of fifty cents is made for each short-term loan granted.

The maximum amount for which a short term loan may be granted, whether for tuition or for other purposes, is sixty percent of the student's total bill to the University for that semester, and cannot be used in conjunction with the deferred tuition plan.

Every student incurring indebtedness to the University is required to undertake to pay the debt in full as rapidly as possible. Prompt repayment of loans insures the availability of a continuing fund to help other students.

Programs sponsored by the U.S. Office of Education. These consist of the Supplemental Educational Opportunity Grant (SEOG) program, the College Work-Study Program (CW-SP), and National Direct Student Loan (NDSL) program. All recipients are selected by the University. The Basic Educational Opportunity Grant program (BEOG) is a federal program making payments directly to the student.

SEOG is for students of exceptional financial need who without this grant would be unable to continue their education. Grants up to $1,000 a year are available for four years of undergraduate study, and are matched with at least an equal amount of University assistance.

CW-SP assists students by providing job opportunities either with the college itself or with private or public non-profit agencies working in cooperation with Lehigh. Students may work an average of 15 hours weekly, with pay determined by the University.

NDSL makes it possible for the University to make loan awards up to $1,500 to needy students. The financial aid officer is responsible for determining eligibility. Repayment begins nine months after graduation or termination of at least half-time study and may extend over a ten-year period. Interest charges of 3 percent also begin at the start of the repayment period. No repayment is required and no interest is charged for any period up to three years of service in the armed forces, Peace Corps, or VISTA. Graduate students are eligible to borrow up to $2,500 per year, with deferment of previous loan repayment.

BEOG is a direct-aid program providing nonrepayable aid for undergraduate study. Applications are available from high school guidance officers and Lehigh's financial aid office. Maximum awards will vary, annually, with the federal funding level.

State programs. These are important sources of both grant and loan assistance. Students residing in Pennsylvania may be eligible for a Pennsylvania Higher Education Assistance Agency grant-in-aid up to $1,200 per year. Current high school juniors and seniors should obtain information from their guidance office. College students are advised to check with the Office of Financial Aid. Lehigh students also have received grant assistance from New Jersey, Massachusetts, Rhode Island and Connecticut.

Guaranty loan programs exist in most states, allowing students to borrow up to $2,000 annually with low interest and deferred repayment. Applications may be obtained at participating lending institutions.

Presidential Prizes. The Presidential Prizes are awarded to entering freshmen based on merit and without regard to financial need. They are described in the Special Academic Opportunities section of this catalog.

Student Services

Counseling and assistance

General counseling of individual students, especially in the freshman year, begins with the residence hall counselors. These counselors are carefully selected upperclassmen, appointed by the president of the University, who help the first-year students and who direct them to more highly specialized aid when needed.

Freshmen (both men and women) whose problems transcend the competence of the residence halls counselors come to other advisors for guidance in many areas of student life and welfare. Problems of vocational choice and academic adjustment are not uncommon, particularly during the freshman and sophomore years. At all levels, academic and procedural questions, personal problems, social adjustment difficulties, and many other troubles are dealt with daily. The office of the dean of students serves as a central agency in helping students to meet their problems and concerns, both through its staff and through referral to other student personnel and academic offices. Members of the dean's staff interview each freshman individually during the first year.

Each student in the College of Arts and Science is assigned a freshman advisor with whom the student discusses academic interests prior to registration. The choice of studies is carefully organized in terms of specific backgrounds of preparation and future objectives. Individual counseling continues throughout the student's four years in the college. In the College of Business and Economics, faculty advisors work with the student concerning his or her individual problems for the same purposes. Similarly, the associate dean of the College of Engineering and Physical Sciences curriculum spends much time with the freshman engineering students in an effort to help in the adjustment of academic difficulties and in better definition of vocational objectives. These forms of advisement are carried on through the following years with the student's academic advisors.

A student's problems often reveal the need of more highly specialized attention, whereupon the student is referred to the particular service which should be consulted. Problems of mental or physical well-being are, of course, referred to the University Health Service which is described in another section. The University Chaplain is available for the student with religious, moral, or personal concerns that are interfering with his or her peace of mind and studies.

If a student is uncertain about vocational plans or needs to know more about his or her own capacities, interests or personal characteristics, the University Counseling Service is available without charge. Confidential interviews may be secured by any student who wishes to review his or her own progress and further evaluate and refine his or her thinking about future goals. Services offered include personal counseling for those students who may need and desire it.

Later, in the senior year, the question of prime importance is the decision of a position after graduation. The Director of Placement, in personal and group conferences, advises on applying for a position, on being interviewed, and on the relative advantages and disadvantages in working for the different business and industrial firms seeking the services of college graduates.

Financial problems can become a serious hazard for a student. The Director of Financial Aid is available for consultation on these problems.

If the student is a veteran of military service and has questions involving relations with the Veterans Administration, he will find the Registrar informed in this field. The Registrar also is an advisor on military service, on matters of transferred credits, graduation requirements, and allied topics.

A serious hazard to success in a student's academic life may be in poor study habits or reading skills. The Reading and Study Clinic can provide help.

Not all student problems are individual problems. Many are group problems, having to do with group living in the residence halls, with student activities, student organizations of many kinds, fraternity life, and campus social life in general. The deans and their aides give much time to these areas of student life.

Many members of the teaching faculty are deeply interested in students and student life and spend a great deal of time working with student groups. They contribute their services as academic advisors, activity sponsors, group sponsors and advisors, by entertaining in their homes, and in friendly personal relationships with students.

In these and in other ways Lehigh University endeavors to maintain the close contacts with students

which characterize the smaller institution. Services are available for all student needs, and the student need only turn to his or her nearest residence hall counselor, professor, or closest campus friend to learn where help can be obtained.

Students' Health Service

A dispensary is maintained which is equipped and staffed for routine medical and minor surgical care. Routine care provided by the regular Health Service physicians, nurses, etc., is provided at no cost to students. Dispensary hours are regular University office hours during the week, and half-day on Saturdays.

A night medical attendant is on duty through the fall and spring semesters. Facilities are available during these hours for the treatment of minor injuries and illnesses. A physician is on call at all times during the fall and spring semesters.

Patients requiring more than a few days of bed care are sent home or to a local hospital when indicated. Expenses so incurred must be paid by the student.

Due to limited staff and multiplicity of dispensary duties, Health Service physicians are not able to make professional calls on students in living groups or in rooms, except in cases of absolute emergency. If unable to visit the dispensary in the event of illness or injury, students are advised to call local physicians for treatment. Such physicians' fees will be paid by the student, the family, or a health insurance plan.

The Health Service desires to work closely with the student's family physician and, as far as possible, will continue any treatment or follow-up requested.

Physical Examinations. Prior to arrival on campus each new undergraduate student is required to submit a Health History Form and Record of Physical Examination completed and signed by the family physician. It is essential that all parts of this form be completely answered by the student and the examining physician to be eligible for registration. At the appropriate time these forms are mailed to new students with specified date for return to the Health Service.

The physicians of the Health Service carefully analyze the results of all physical examinations in order to detect any latent or obvious physical, emotional, or mental abnormality. When found, a person involved may be invited for a conference and the disability discussed with the student confidentially.

Close cooperation between the athletics and recreation department and the Health Service permits the establishment of rehabilitation measures, etc., as indicated.

Immunization. All new and transfer students are required to show evidence of immunization to, or booster dose of tetanus toxoid vaccine within the last six years.

Laboratory. Facilities are available for routine laboratory procedures. Additional procedures are performed at a local hospital at the expense of the student.

Physiotherapy. A well-equipped physiotherapy section is a valuable adjunct to the University Health Service. A well-trained technician administers treatment under the supervision of the University physicians with such equipment as diathermy, whirlpool, and ultraviolet and infrared lamps.

Personnel. Full-time Health Service personnel normally include three physicians, a physiotherapist, a laboratory technician, two registered nurses, two night medical attendants, an administrative assistant, and a receptionist.

Accident and sickness reimbursement insurance. The University offers students insurance coverage against accident and sickness at nominal cost, and on an entirely voluntary basis.

The Health Service highly recommends this insurance plan to both present and prospective students. Past experience has emphasized the importance of such protection. All students are urged to participate in this plan throughout their college careers. The policy covers such items as prescription drugs, outpatient X-rays, and consultations which are not covered by the usual hospitalization policies.

All foreign students and others who, in the opinion of the administrative officers of the University, may not be in a position to meet the costs of accident or sickness are usually required to carry insurance.

Counseling Service

The University is actively interested in the progress of its students as they pursue their educational and personal goals and wishes to provide assistance should difficulties arise during their college years. The Counseling Service, located in the Health Center, offers the opportunity for consultation with clinical psychologists and other counselors in regard to a wide variety of problems ranging in severity from those concerns that arise during the course of normal development to more debiliting emotional disturbances.

In cases where pertinent and objective information

about academic ability, vocational interest or social-personal adjustment is desirable, psychological tests are often administered. Such test batteries are available at every student's individual option. Interpretation of these tests is intended to help the student achieve maximum effectiveness in his or her course work and studying, professional development and campus life. The test scores are utilized as only one of a number of sources of information important to wise and effective planning. A library of educational and occupational information is maintained by the Counseling Service, to which students can refer as they attempt to develop a clear conception of the educational and vocational world and their place in it. Additionally, cross-communication with other University personnel agencies is maintained in gathering together information and expediting plans made cooperatively with the student.

When a student is generally uncertain, confused and unable to plan for the future with confidence, or experiencing frustration with his or her studies and choice of major, or very unhappy about his or her social success and ability with people, he or she may undertake personal counseling aimed at helping the individual understand his or her direction and motivation. Psychotherapeutic counseling, in particular, encourages the student to explore the sources of his or her feelings, to consider their influence on behavior and to discover new ways to manage one's own affairs more effectively. In these instances personal psychotherapeutic interviews would be intensive and likely to involve conferences over an extended period of time.

Both testing and counseling services are available, without cost, to all University students and all interviews are held in confidence.

Although student counseling is its major professional activity, the Counseling Service is also the administrative center of a variety of local and national testing programs in which students might wish to participate during their college career. The most frequently administered of these programs are the Graduate Record Examination, Law School Admission Test, the Admission Test for Graduate Study in Business, National Teacher Examination and Miller Analogies Test.

The Service also engages in research on tests, counseling and other functions. The results of such research are ultimately useful in the counseling of individual students.

Placement Services

The University provides centralized placement services for engineering, business, and arts and science seniors, graduate students, and alumni seeking to meet their postgraduate plans. Among the objectives of Placement Services, located in Christmas-Saucon Hall, is to help students learn the dynamics of the investigative and decision-making processes involved with postgraduate plans. An additional objective is to help students and alumni learn how to seek, interpret, and integrate career and occupational information into their interests, objectives and goals.

Each year, several hundred employers send representatives to Lehigh to interview candidates. In addition to on-campus interviews, many employers seek candidates by direct referral. The Placement Services staff helps to arrange interviews for prospective employers by means of an intricate and effective system of information flow between employer and student. In addition, the staff serves as a resource for students and alumni as they develop professional goals and career plans. Current occupational information and assistance for students seeking summer employment also are provided.

Reading and Study Clinic

There are many factors which influence the performance of college students. An important one is the expertise with which they master the skills necessary for college work. High-level skills are needed in preparing assignments, note-taking, outlining, listening, recalling information and facts, taking examinations, preparing written and oral reports, and reading critically and accurately.

The Reading and Study Clinic of the University's School of Education offers Lehigh students an opportunity to develop satisfactory reading and study habits. The following services are available to all students: analysis of reading and study skills, reading and study improvement programs, and individual guidance on problems of academic adjustment.

First-year students, particularly, are encouraged to arrange for a conference so that they can be assisted in making an evaluation of their learning tools and in planning for more effective work.

The improvement programs are offered periodically during the fall and spring semesters. Small group instruction is scheduled for interested students. The

instruction is adapted to the needs of the individual in well-equipped facilities located in the Saucon Valley education complex.

Student activities and events

Extracurricular activities provide special opportunity for students to develop leadership, to participate in interest groups and programs of their own choosing, and to learn cooperation and group activity. At Lehigh the philosophy of extracurricular activities is to allow the students as much opportunity as possible for setting their own policies, devising their own programs, and assuming full responsibility for their organizations. This philosophy makes it possible for the activities to be extremely significant in the personal development of participants.

The University Forum

To give students a voice in all Lehigh affairs, a University Forum, composed of 60 students, 60 faculty, and five members of the administration, was established in 1970 as the primary campus legislative body.

The University Forum has legislative responsibility in setting policy on academic program and planning in such areas as freshman seminars, high immediate relevancy courses, and the academic calendar; social life and regulations, extracurricular activities, and athletics; and areas of academic environment such as pass-fail grading, admission, registration, residence and dining hall facilities, the libraries, bookstore, and computer. The Forum also has the authority to review with recommendations to the board of trustees or other appropriate bodies, programs in long-range planning, such as academic development, staff requirements, physical facilities, and the over-all budget of the University; community relations programs; administrative appointments at the rank of dean and above; and matters pertaining to curriculum, research, and academic discipline.

While the board of trustees as the ultimate legal authority of the University retains the authority over all transactions of the University, the strength of the Forum lies in the establishment of a representative legislative body composed of equal numbers of students and faculty, so that there is a place where a valid project may be carefully considered. All meetings of the Forum are open to the community, with the right to address the Forum provided to any person desiring to do so. The Forum meets in the University Center.

Honorary and Recognition Societies

Honorary scholarship societies at Lehigh include Phi Beta Kappa (the oldest national honorary society), Tau Beta Pi (national honorary engineering society organized at Lehigh in 1885), Sigma Xi (pure and applied science), Beta Gamma Sigma (business administration), Phi Eta Sigma (freshman honorary), and fifteen other national honorary and recognition societies. These recognize service or achievement in different fields of study as well as leadership.

Volunteer Service

Varied opportunities for student expression of social responsibility exist through programs sponsored by the Lehigh University Volunteers (LUV) and the Office of the Coordinator of Volunteer Community Services. More than 300 Lehigh students currently participate in volunteer service efforts in the Lehigh Valley area in a range of service programs. LUV is governed by a board composed of coordinators of its various projects.

Most of the volunteer work is done in cooperation with community agencies or schools. Some of the projects include tutorial and teaching aide programs in public and private schools, recreation activities through the YMCA and neighborhood centers, Big Brothers, companionship and group work with children and adults in residential mental health treatment facilities, aid to the elderly in institutions and at home, income tax service at neighborhood centers, blood assurance, and numerous individual and short-term efforts.

The Volunteer Community Services Office also coordinates programs involving the Peace Corps, VISTA, the American Friends Service Committee, and Crossroads Africa, a program through which North American college students devote their summers to community work projects in Africa supervised by Africans.

The LUV office is located in room 202, University Center.

Student Interest Associations

At Lehigh, student organizations embrace a wide range of activities. Course societies promote intellectual interests in various fields of study and develop professional spirit among the students. Interest and hobby groups include art, bridge, chess, camera, languages, sailing, skiing, boxing, judo and political clubs. Fencing and hang-gliding are recent additions.

The musical organizations (band, orchestra, chorus, glee club, chamber singers, and instrumental ensembles) provide group training for qualified students, present concerts and combine their talents in several annual programs. Lehigh's marching band, one of the finest in the East, is well known for its precision drills at football games. During the winter-spring season, the concert band is formed and several major performances are given on and off campus. Both the concert band and the recently established wind ensemble draw heavily upon the music of living composers. The glee club sings with choirs of various women's colleges and has toured in England, Ireland, Wales and the Caribbean. The glee club joins with the women's singing group (the chamber singers) to perform in concerts and at chapel services. The string orchestra (formed in the fall of 1973) has grown and expanded to include in its repertoire music for the small orchestra. The chamber music program encompasses the music from Renaissance consorts to the modern wind ensemble literature. The music program at Lehigh is uniquely nonmusic-major oriented.

The dramatic society of Lehigh, known as Mustard and Cheese, presents several productions a year and a series of special films. Of particular interest to many students is the frequent showing of foreign and American art films.

The students publish a semi-weekly newspaper, the *Brown and White,* and a yearbook, *The Epitome.* The students' radio stations, WLRN, 640 kc., and WLVR-FM, 91.3 MH_Z, both broadcast throughout the day. Students also operate their own television station, WLTN, Channel 2.

A student-operated coffeehouse which seats about fifty people is located in the undercroft of Packer Memorial Church. It is known as the Catacombs.

Religious Activities

The religious program is under the general supervision of the University Chaplain, who also provides for Protestant chapel services, broadly based and ecumenical in form, varying from the traditional to the informal and innovative. Some services feature the Lehigh University Glee Club while others utilize folk music. Roman Catholic masses are arranged by the Chaplain for Catholic students.

The regular Protestant and Roman Catholic service schedules are announced at the beginning of the year. Attendance at all religious services is voluntary. The university is nondenominational.

The Chaplain's Council, consisting of representatives from the various religious groups of all faiths on campus, sponsors a variety of programs together with those organizations and separately under the Chaplain's Office. The Council has sponsored, for example, a luncheon program and a film series, both with discussion, talks by religious leaders and faculty members, and multi-media presentations. Council programs are open to all students.

The Newman Club carries on a program among Catholic students under the guidance of a priest assigned by the Diocese of Allentown to direct the program. The Hillel Foundation program is available to students of the Jewish faith, while various Protestant churches in the community include fellowship organizations for Lehigh students in their programs.

Athletics

Lehigh's intercollegiate program consists of varsity teams in football, cross-country, soccer, wrestling, basketball, hockey, rifle, swimming, tennis, track, baseball, lacrosse and golf; junior varsity teams in football, wrestling, basketball, swimming, and baseball; and freshman teams in most of these sports. Schedules are arranged chiefly with eastern colleges which have athletic policies similar to Lehigh's. Six varsity sports are available for women.

Normally Lehigh's athletic schedule includes four or five home football games, six or seven home wrestling meets, nine or ten home basketball games, nine home baseball games, and four home swimming meets as well as games or meets at other colleges in these and other sports.

A comprehensive intramural sports program is sponsored for the entire University, including teams from the residence halls, fraternities, classes, town, faculty, graduate students, and independent groups. Twenty-four sports activities are included in the program. Students are encouraged to participate in these

recreational sports, and awards are given for group and individual excellence.

Special Events

Students are encouraged to attend the many musical, theatrical, and special events on the Lehigh calendar. Concerts of great variety and depth are arranged by the music department, the Music at Lehigh committee, the Cleaver Foundation, the Student Activities Council, and the music organizations of Lehigh. The Music at Lehigh concert series is managed by a student committee and the music department and brings to the campus from twelve to fifteen concerts each year. Recent Music at Lehigh concerts have included the Philadelphia Composers' Forum, the Music for a While Consort, Morton Subotnik (electronic and multimedia concert), the Nu Liberation Art Unit, the Goldovsky Opera Company and the Temple University Symphony. In conjunction with choruses of women's colleges, the glee club has performed choral masterpieces including the Stravinsky-Cocteau opera-oratorio, *Oedipus Rex,* Britten's festive cantata *Rejoice in the Lamb* and the Haydn *Mass in B Flat (Harmoniemesse).* The Winter Concert is the first major performance given by the Concert Band. Recently, a retrospect of music by composer Henry Brant was featured. The band's annual Pops Concert, presented by the Concert Band at the end of the spring semester, is one of Lehigh's most popular events.

Among the outstanding speakers brought to the Lehigh campus in recent years, in addition to scholars in many academic disciplines, were Charles Goodell, Gene Rodenberry, Wernher Von Braun, William Proxmire, Samuel Dash, Carl Rowan, Joseph Heller, Isaac Asimov, and Pennsylvania's governor, Milton Shapp. Many of these speakers have appeared under the auspices of the Forum for Visiting Lecturers, which sponsored Nobel Prize nominee Elie Wiesel in February, 1975.

A noteworthy feature of the special events calendar for any year is the annual Jacob Blaustein Lectures in International Relations series which presents an outstanding public figure speaking on crucial questions of international relations. Lecturers have included General Maxwell D. Taylor, Belgium's Paul-Henri Spaak, Israel's Abba Eban, Averell Harriman, James Reston, Harold Wilson, and, in 1975, Dean Rusk, former U.S. secretary of state. The lecture series was established through an endowment gift from the Jacob and Hilda Blaustein Foundation of Baltimore. Mr. Blaustein, Class of 1913, was a pioneer in the petroleum industry and an international statesman of some note.

In 1971 the Berman Lectures in Economics began with Paul Samuelson, the Nobel Prize winner. The series is sponsored by Mr. and Mrs. Philip I. Berman, of Allentown, Pa., who are philanthropists and art collectors. Among recent speakers was John Kenneth Galbraith, the noted economist.

The Mellon Lectures, which are concerned with the relationship of man with technology, have brought experts in that subject area to the campus. The 1975 speaker, Melvin Kranzberg, appearing April 22-23-24, founded the Society for the History of Technology. The 1974 speaker, Professor Carroll Pursell, formerly of the University of California at Santa Barbara, now holds Lehigh's Mellon chair in the history of the humanities.

The Department of Fine Arts arranges a series of monthly exhibits in the art galleries of the Alumni Memorial Building and DuBois Gallery of Maginnes Hall with works by contemporary American artists, as well as architectural, photographic, and student art shows. The University's permanent collection of art is displayed in several buildings on the campus. Represented in the collection are paintings by such masters as Goya, Gainsborough, Reynolds, Courbet, Sisley, Redon, Vuillard and Bonnard, which are displayed on special occasions. The gifts of Mr. and Mrs. Ralph L. Wilson have provided the collection with examples by American painters and printmakers including "the Eight", Johns, Katz, Rauschenberg, Motherwell and Hayter.

University Regulations

Academic information

The following information concerning academic and other requirements and regulations should be of special interest to all students enrolled at the university.

Eligibility for degree

In order to be graduated, a candidate for a baccalaureate degree must achieve a minimum cumulative average of 1.9.

To be eligible for a degree from Lehigh University, 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 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.

Final date for completion of requirements

For graduation all requirements, scholastic and financial, must have been satisfied prior to the graduation exercises.

Notice of candidacy for degree

Candidates for graduation on University Day file with the Registrar on or before March 15 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 in October file a notice of candidacy on or before September 10. Failure to file such notice by the dates mentioned debars the candidate from receiving the degree at the ensuing graduation exercises. If a petition for late filing is granted, a fee of $10 is assessed.

Graduating theses

Undergraduate theses, when required, are accompanied by drawings and diagrams, whenever the subjects need such illustration. The originals are 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.

Credit and grades

A semester hour of college work consists of one hour a week of lectures or classwork, or two or three hours of laboratory work (or laboratory work combined with classwork) a week for one semester. The normal assumption is that the student will be expected to do at least two hours of study in preparation for each hour of classwork.

Latest date for registration. No registration is accepted later than the tenth day of instruction in any semester.

Grading system. Final grades in courses are A, A-, B+, B, B-, C+, C, C-, D+, D, D-, F. The key to grades is as follows: A—excellent; B—good; C—continuation competency, defined to mean that the student has achieved a level of proficiency such that the instructor believes that he or she is prepared to take any subsequent course which has this course as a prerequisite; D—unsatisfactory, but passing, defined to mean that the student has achieved a level of proficiency such that he can apply the course toward graduation, but in the estimate of the teacher he or she has not acquired adequate proficiency to perform satisfactorily in any subsequent course which has this course as a prerequisite; F—failure. Courses taken under the Pass-Fail system are graded P (passing) or F (failure).

A freshman who withdraws from a course during the first seven weeks of instruction will receive a grade of "W". All other students who withdraw from a course after the above dates will receive "WF" unless the Committee on Standing of Students, for cause, allows a grade of "W" to be recorded.

A student officially withdrawn from the University after the above dates receives from each instructor a "WP" or "WF."

The letters "Abs." (absent) are used to indicate absence from a final examination in a course. The grade of "Abs." is reported with a letter grade in parentheses, such letter grade representing the department's estimate of the student's work up to the close of instruction with the provision that in cases where a department does not feel justified in reporting an estimated grade, a report of "Abs. (X)" will be returned.

The letters "Inc." are used to indicate that the

work in a course is incomplete. In such cases, an appropriate letter grade shall accompany the "Inc." designation (e.g., "Inc.[B]") if the instructor has sufficient basis to report such a grade. Otherwise, the grade shall be reported as "Inc.(X)." A student who incurs an "incomplete" in any course and fails to remove the "incomplete" within one calendar year, loses all equity in the course.

Pass-fail system. The pass-fail grading option is intended to encourage student exploration of challenging courses that would normally be avoided for fear of depressing grade-point averages. It is intended particularly for exploration outside the major field. Students should avoid wasting this option on unsuitable courses, such as certain basic introductory courses having no college-level prerequisite or corequisite. The restrictions on the use of the system are listed below.

Students who desire to take particular courses pass-fail shall consult (at the time of preregistration) with their curriculum directors or registration advisors for guidance in this area. Each curriculum director or registration advisor should consider the intent of this system and the demands of the particular curriculum, then formulate suitable guidelines to aid students in the intelligent use of this option. At the same time, instructors should be prepared to advise particular students as to the suitability of their particular courses for the pass-fail option.

The restrictions on the use of the system are:

1. Before a student can take a course pass-fail, he or she must have achieved sophomore standing, have declared a major, and be in good academic standing.

2. A student may take no more than two courses pass-fail in any one semester. He or she may take a maximum of six courses pass-fail per undergraduate career if engaged in a four-year program or a maximum of eight courses per undergraduate career if participating in a five-year, two-degree program.

3. No course may be taken pass-fail that satisfies any part of the graduation requirements for the major.

4. A student must have the registration advisor's approval to take a course pass-fail. A student must designate the course(s) taken pass-fail by the tenth day of instruction in a regular semester or the fifth day of instruction in any summer term. Prior to this deadline, the student may transfer from pass-fail grading to regular grading or vice versa without penalty. After this deadline, the student cannot transfer from regular grading to pass-fail grading or vice versa.

5. The instructor giving the course is not officially notified which of the students is taking the course pass-fail. Therefore, he or she reports a regular letter grade for the pass-fail students. The registrar then records "P" for reported letter grades of A, B, C and D including + and - and an "F" for a reported letter grade of F.

6. Under this system, the student does not receive the letter grades of A, B, C or D if he or she passes the course. A passing grade shall apply to the student's graduation requirements but shall not be used in the computation of the cumulative average. An F grade shall be computed in the normal manner.

Grade values and probation

The scholastic requirements for each student are expressed in terms of a cumulative scholastic average (the weighted point average of all grades received while in residence). The cumulative scholastic average will be computed at the end of each semester (and full summer session, i.e., one in which 12 or more semester hours have been rostered). Grades are weighted as follows: A=4, A-=3.7, B+=3.3, B=3, B-=2.7, C+=2.3, C=2.0, C-=1.7, D+=1.3, D=1.0, D-=0.7, F=0.0. WF, Abs. (F), Inc. (F), 0. If a course in which a D+ or lower grade was received is repeated, the grade received upon repetition of the course shall be counted in the cumulative average, and the grade(s) and credit hours received when the course was previously taken will be dropped from the cumulative average. W, WP, Abs. (X), and Inc. (X) grades are not included in averages. WF is counted as an F. When grades of "absent" or "incomplete" include a letter designation, this letter shall be used in determining the average.

Probation. A student will be placed on scholastic probation when either:

(a) The individual's cumulative scholastic average falls below these levels:

freshman, first semester 1.00
freshman, second semester 1.00
sophomore, first semester 1.60
sophomore, second semester 1.70
junior, first semester 1.80
junior, second semester and thereafter 1.90

(b) The person fails more than seven semester hours in one semester.

The designation "freshman, first semester," etc., is the classification officially determined by the Registrar irrespective of the number of semesters the student has attended college.

Disabilities of scholastic probationers. A student who is on scholastic probation is ineligible for (a) intercollegiate competition and all other activities publicly representative of the University, (b) major office, elective or appointive, in any University organization, and (c) such other activity as may require more time than should be diverted from primary purposes by any student whose academic survival is at risk. All students, however, have the right to petition to the Committee on Standing of Students for exceptions.

Removal from probation. A student who has been placed on scholastic probation is restored to good standing if at the end of the next semester or full summer session all incompletes incurred during the previous semester have been removed and if the student meets the standards indicated.

Dropped for poor scholarship. A student who makes a 2.40 average or better in his probationary semester but fails to meet the standards set forth in (a), page 25; is continued on scholastic probation for another semester. A student who makes less than a 2.40 average in the probationary semester and fails to meet the standards set forth in (a) will be dropped for poor scholarship.

Honors opportunities

There are three kinds of honors, namely: class honors, graduation honors and departmental honors. (See Special Academic Opportunities, page 33.)

Class honors. Upon completion of the work of the freshman and sophomore years, on recommendation of the Registrar and by vote of the faculty, class honors are awarded to those individuals who have made an average of 3.00 or better during the preceding academic year.

The names of these students are announced at the Founder's Day exercises and printed in the program.

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 their junior and senior years' work at the University.

Degrees "with high honors" are awarded by vote of the University faculty to those students who have an average of not less than 3.50 in their junior and senior years' work at the University.

Degrees "with highest honors" are awarded by the vote of the University faculty to those students who have an average of not less than 3.75 in their junior and senior years' work at the University.

Students who spend all or part of their junior or senior years at another institution may qualify for graduation honors under the following conditions:

1. The student must have at least 90 hours of work at Lehigh and an average during the last four semesters in residence at Lehigh which qualified him or her for graduation honors. This average determines the highest category of graduation honors that it is possible for the student to attain.

2. The student's average at the other institution when computed with the last four semesters at Lehigh must be such as to still qualify the student for graduation honors. This average may lower the overall average of the student from one category of graduation honors to another one.

Graduation honors are announced on University Day and published in the commencement program.

In all cases, it is required that each student have not less than forty-eight hours of work graded A, B, C, D, or F, including + or - designators.

In computing the averages of candidates for graduation honors, semester grades are weighted according to the number of credit hours in the course concerned.

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 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 the period; for example, at the hours when they meet classes during the formal instruction period. No quiz may be given during the eight-day period before examinations.

The university and the student

Lehigh 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 aca-

demic 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 Lehigh 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 which the University regards as essential to its educational objectives and to community living.

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. An emphasis on counseling and learning will accompany such action.

All members of the University community are subject to municipal, state and federal laws. Obviously the University cannot be a sanctuary for persons who violate these laws. Lehigh is concerned, however, about the rights of students as citizens (with equal protection under the law) and will direct them to legal counsel when necessary.

For just cause (relating to the educational purposes of the University) Lehigh reserves the right to review actions taken by civil authorities against its members. Although ordinarily Lehigh will not impose additional sanctions after criminal disposition of the case, it does have the obligation to introduce counseling and/or disciplinary action if the person's conduct has interfered with the University's exercise of its educational objectives or responsibilities to its members. Further, the University as a part of the community has an obligation to report serious crimes to the appropriate civil authorities.

Lehigh relies primarily on general principles and statements of expectation for the guidance of conduct, and assumes that those admitted to the University community are capable of governing themselves accordingly. Specific regulations are kept to a reasonable minimum and are published in the *Lehigh Handbook*. These regulations govern academic honesty and social conduct (including drugs, alcoholic beverages, motor vehicles, etc.). Copies of the *Lehigh Handbook* are made available to every student through the Office of the Dean of Students. Students are responsible for knowing the procedures, rules and regulations as published in the *Handbook*. Freshman residential students should note that permission is *not* granted to them to have motor vehicles on the campus.

Violations of the Student Conduct Code are adjudicated by the Committee on Discipline which operates under the principles of due process.

Regarding dissent, the University faculty has a policy which emphasizes the responsibility of all members of the University community. The guidelines adopted broadly set forth acceptable forms of dissent on campus.

Generally, the policy on dissent provides the following:

(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 function. 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 which 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 its Committee on Discipline.

Equal opportunity

Lehigh University employs a full-time affirmative action officer to help the university improve the status of women and minority groups, particularly blacks, Asian-Americans, American Indians and Spanish-surnamed Americans. Lehigh's affirmative action plan provides for broadened recruitment, hiring, promotion, upgrading and other employment procedures. Students are assured equal access to services and facilities regardless of their sex, race, national origin or religion.

Environment and Resources

Lehigh is an admixture of the new and the old. While a few buildings date back to the university's earliest years and retain the "Railroad Gothic" architecture popular at that time, there has been considerable development of the physical plant in recent years, especially since 1964. Projects under way as of March, 1975, include a $7 million chemistry complex, the $2 million Sherman E. Fairchild Solid State Studies Laboratory, and a new fieldhouse on the Saucon Valley campus. Not including these buildings and major renovations now in progress, Lehigh has constructed during a ten-year period some 26 structures comprising some 719,475 square feet of space. The aggregate cost of these structures was about $27 million. Including residential structures, Lehigh now has more than 100 buildings, with academic buildings grouped on the lower campus and most residential facilities higher up on the mountainside.

The following listing provides brief descriptions of those buildings most frequented by students and faculty, as well as an introduction to the educational facilities. A map which may be found on the back pages of this catalog shows the location of these buildings as well as residence halls.

The Alumni Memorial Building, the administrative center of the university, was built as a memorial to Lehigh men who served in World War I. The Gothic structure houses the offices of the president and his staff, the treasurer and the business offices, the registrar, admission, development, financial aid, public information, and alumni association offices. Exhibitions of paintings, drawings, prints or sculpture by a variety of professional artists are presented in the building's galleries. These exhibitions are changed every few weeks.

One of Lehigh's most interesting buildings is the immense University Center, a Railroad Gothic structure which was one of the original buildings given to the university by its founder. A special railroad was constructed to the site to bring the stone required for construction. Originally known as Packer Hall, the structure served a number of purposes over the years until its interior was reconstructed in 1958. At the

time of renovation, an extensive addition was constructed to the south and west of the original structure. Now known to students as the UC, the building houses student, faculty and guest dining facilities, a snack bar, offices of the Forum, the Organization for the Enhancement of Afromanity Cultural Center, the student newspaper and radio stations, and a variety of lounges and meeting rooms. The dean of students maintains offices in the building.

Just below the UC is another early building, the President's House. The occupant at this writing, Dr. Deming Lewis, has served as president since 1964.

The Packard Laboratory was the gift of James Ward Packard, founder of the Packard Motor Car Company and an 1884 Lehigh graduate. The building houses the offices of the dean of the College of Engineering and Physical Sciences, classrooms, and laboratories of the departments of electrical, industrial, and mechanical engineering and mechanics. The Computing Center with its Control Data Corporation (CDC) 6400 computer is located in Packard Lab. A feature of the building is a 600-seat auditorium located on the ground floor. The first Packard automobile is housed in the lobby, located on the third floor of the building.

Christmas-Saucon Hall has historic interest because half of the building, Christmas Hall, was the university's first structure. The building has offices and classrooms primarily used by the department of mathematics, as well as office facilities for the university placement service.

Fritz Engineering Laboratory is named for John Fritz, known as the father of the steel industry in the United States and a member of Lehigh's original board of trustees, who in 1909 provided funds for a laboratory. In 1955, a seven-story addition to the original structure was opened. It houses a universal hydraulic testing machine, capable of applying a five-million-pound load to tension or compression members up to forty feet in length. Equipment for applying loads to structures, the latest strain and repeated deformation measuring instruments, and impact and hardness testing machines are also available. The lab is used by the department of civil engineering for offices, various research projects, and for laboratory work in conjunction with instruction in the mechanics of materials, hydraulics, and properties of cement and concrete.

Packer Memorial Church, a gift of the late Mary Packer Cummings, daughter of university founder Asa Packer, was built in 1887. The church is considered to be a masterpiece of handcraftsmanship. Sunday services, special religious programs, recitals, and the annual Bethlehem Bach Festival are held in the church. A coffeehouse operated by students is located in a basement area known as the Catacombs.

Taylor Gymnasium and Field House were donated by the late Charles L. Taylor, class of 1876. The gymnasium includes a swimming pool, 75 by 42 feet, ranging in depth from five to ten feet; five basketball courts; weight room; fencing room; and class and meeting rooms. Adjacent to the gymnasium and field house is Taylor Stadium, which provides football and baseball fields, and has a seating capacity of 16,000 persons. The gym and fieldhouse were scheduled for renovation during 1975 while work continued on construction of a new 62,000-square-foot fieldhouse on the Saucon Valley campus where other athletic facilities, including the Varsity House and a squash court, also are located.

The Physics Building is a five-story structure devoted to the teaching of and research in physics. It contains laboratories for undergraduate and graduate classes, research laboratories, reading room, and shops. Extensive renovations were completed in 1960-61.

The aforementioned $7 million chemistry complex, which will be available for the use of students arriving in September, 1975, includes two major units. These are the seven-story-high Seeley G. Mudd Building, housing laboratories and classrooms, and the adjoining low-rise building which houses three auditoriums. The chemistry tower has been especially designed to provide for good ventilation of individual laboratories, a benefit that many student chemists will appreciate.

Lehigh has two other chemistry facilities. They are the William H. Chandler Chemistry Building, which honors a former president of the university who had taught chemistry from 1871 to 1906, and the adjoining Harry M. Ullmann Chemistry Laboratory, named for a former department chairman. These buildings, formerly utilized for undergraduate education, now serve as home base for two of the university's affiliates, the Institute for Pathobiology and the Center for Marine and Environmental Studies.

Sinclair Laboratory, a gift of the late Mrs. Jennie H. Sinclair and named for her late husband, Francis

MacDonald Sinclair, houses the Center for Surface and Coatings Research (CSCR) and the National Printing Ink Research Institute.

The university libraries include Linderman Library, which incorporates the original library rotunda, a gift of the founder and named in memory of his daughter, Lucy Packer Linderman, and a Gothic edifice built in 1929, and the Mart Science and Engineering Library, opened in 1969.

Linderman Library houses 550,000 volumes in the humanities and social sciences, the Rare Book Collection of 6,000 volumes, and the University Archives. Collections are particularly strong in the classics, English literature, and British colonial history. The annual acquisition rate averages about 15,000 volumes. The library receives over 4,500 periodicals and serials, including important newspapers, both foreign and domestic, and has long been a depository for a wide selection of U.S. government documents. A feature of Linderman Library is the music listening room located on the ground floor. The building also houses the offices for the library, research, administrative systems, university publications, and physical planning staffs.

Mart Library houses 100,000 volumes in the fields of engineering, mathematics, and natural and physical science, and includes an all-night study room. The three-story structure is named for two deceased alumni from Kansas: Leon T. Mart, class of 1913, and his son, Thomas L. Mart, class of 1951.

Whitaker Metallurgical and Chemical Engineering Laboratory, a five-story building with a two-story classroom wing, opened in 1965. Among the more than twenty separate areas for scientific and engineering investigations are laboratories for high pressure research and reaction kinetics, nuclear studies, analog computation, process control, high temperature thermodynamics and kinetics, analytical studies, and fine structures and metallography. The classroom wing includes an auditorium-lecture hall with a seating capacity of 225.

Maginnes Hall, a multi-level structure opened in 1970, is home base of the College of Arts and Science, and houses offices and classrooms for the departments of English, history, government, international relations, classics and religion.

The University Bookstore is located on the ground floor of Maginnes Hall. In addition to all required textbooks and supplies, the bookstore carries a large selection of paperback and hardcover books, stationery items, specialized engineering requirements, and an assortment of greeting cards, phonograph records, posters, magazines and newspapers, and sundries.

Williams Hall, donated by the late Dr. Edward H. Williams, Jr., class of 1875, professor of mining and geology at Lehigh for 21 years, contains classrooms, laboratories, and museum collections of the departments of biology, geological sciences, and psychology. The building was renovated in 1956, when a fourth story was added.

Grace Hall was named for its donor, Eugene G. Grace, who was a member of the class of 1899 and served as president of the board of trustees from 1924 to 1956. The building is used primarily for basketball and wrestling, and also serves as an assembly room for concerts and lectures. It seats more than 3,000. The top floor provides classrooms and offices for the Department of Military Science and the Department of Aerospace Studies.

Coppee Hall, named for the first president of Lehigh, contains offices and classrooms for the departments of fine arts and speech. Some foreign language offices are also housed in this building, which originally served as the university gymnasium.

Drown Memorial Hall was erected by friends and alumni as a memorial to the late Dr. Thomas M. Drown, fourth president of the University from 1895 to 1904. It provides offices, classrooms, reading rooms, and lecture rooms for the dean and departments of the College of Business and Economics.

Lamberton Hall houses the department of modern foreign languages and literature. The department of music also uses the building, with rehearsal rooms for the band and glee club.

Just above the University Center is the Health Center, a stone structure built in 1959, where medical service for students is available around the clock. The building also houses the university personnel office, the office of the dean and vice president for student affairs, the motor vehicle office, the physiotherapy facility, the counseling service, the office of the director of community relations, and offices of the Fraternity Management Association.

Renovation began during 1975 on the Wilbur powerhouse, which has been superseded by a contemporary powerplant. The old powerhouse is being transformed into a small theater supportive of the university's drama program.

Rathbone Hall, situated on a bluff above the Centennial II and below the Centennial I residence complexes, provides a glass-walled dining facility in which undergraduates may dine with a spectacular view of the Lehigh Valley. The lower area of the building houses the offices of residence officials.

Other residential facilities include Dravo, Drinker and Richards Houses (the so-called "freshman quad"); McClintic-Marshall House; Taylor House; Bishopthorpe Residence; and the newly completed Residence Hall 11 complex for undergraduates, featuring seven buildings with small apartment units. During 1974, the university completed the Saucon Married and Graduate Students complex on the Saucon Valley campus; these garden apartments range from efficiencies to three-bedroom units.

There are 31 fraternity housing units on or near the campus. These houses are listed in the section on fraternities elsewhere in this catalog.

Other buildings of interest include the Centennial School complex in the Saucon Valley; a building housing the philosophy department; Price Hall, home of the social relations department; the Center for the Application of Mathematics building near the campus; Sayre Psychology Laboratory, and a number of smaller structures.

The Sayre Park area near the top of the campus, where many of the fraternities are located, adjoins the university nature preserve where animals and flowers may be found. The Lookout, with an elevation of 640 feet, affords an excellent view of the valley.

Athletics and Recreation

Professor

William Bader Leckonby, B.S., *Director*

Associate Professor

John Stohler Steckbeck, M.Sc.

Assistant Professors

John Nelson Covert, B.S.
Frederick Homer Dunlap, B.A.
Gerald Grant Leeman, B.A.
Anthony Packer, B.S.
B. Thayer Turner, B.S.

Instructors

N. Craig Anderson, M.S., *Business Manager*
Joseph A. Biedron, B.A.
Helen Bond, B.S.
Barbara Everhart, B.Sc.
Barry J. Fetterman, B.S.
Bruce Gardner, M.Sc.
Thomas M. Gilburg, B.A.
Brian Hill, B.A.
John L. Luckhart, M.Sc.
Charles R. McNaron, B.S.
Thomas Pugliese, B.A.
Samson L. Sanders, M.Ed.
Stanley R. Schultz, B.A.
John Calvin Whitehead, B.S.

The department of intercollegiate athletics and the department of recreation and intramural sports supervise the entire field of intercollegiate athletics, recreation and intramurals at the university. Activities consist of intercollegiate athletics, intramural athletics, and physical education, including corrective exercises and recreational activities.

Experience indicates that it is essential that the intramurals and recreation programs emphasize the physical fitness and efficiency benefits to be derived from a well-rounded and athletic phase of the program. The purpose of the athletic, recreation and intramural sports program is designed to: (1) raise and maintain the physical standards of the university; (2) develop and maintain a high level of all-round physical fitness so that undergraduate men and women may more readily assimilate instruction; (3) encourage regular and healthful exercise by the development of skills, techniques, and attitudes; (4) foster an aggressive and cooperative team spirit, to increase the confidence of the individual, to develop sportsmanship, and to increase university pride through parti-

cipation in vigorous competitive athletics.

Facilities for accomplishing these are afforded in Taylor Gymnasium, Grace Hall, Taylor Field, and Sayre Park Field, the latter an area of seven acres located above the Lookout on top of South Mountain and only a short distance from fraternity houses and residence halls. Saucon Valley Fields are located south of the campus. The six hundred acres there have the following facilities: all-weather quarter-mile track, nine all-weather tennis courts, lacrosse and soccer fields, three football practice fields, Varsity House, two baseball diamonds, twelve to sixteen intramural fields, and a football field. The area is the site of a future athletics and convocation center that will seat 6,000. Almost all of the outdoor intramural sports contests and all upperclass intramural activities are held in the Saucon Valley area; a shuttle bus service is provided to and from this field.

The Saucon Valley athletic complex, in addition to the aforementioned Varsity House, also features recently constructed indoor squash courts. Construction on a new 60,000-square-foot fieldhouse is expected to be completed in the summer of 1975; the facility will include an indoor track. An additional baseball diamond also is planned near the fieldhouse in the near future.

Department of Intercollegiate Athletics

The department of intercollegiate athletics offers opportunity to undergraduate men and women to participate in intercollegiate competition both at home and away with institutions which are Lehigh's traditional rivals and also other institutions which are at some distance.

The intercollegiate program consists of varsity teams in football, cross country, soccer, wrestling, basketball, swimming, tennis, track, baseball, golf, lacrosse, hockey, squash, winter track, and rifle. In addition, there are junior varsity and/or freshman teams in all of the above.

Department of Physical Education, Intramural Sports and Recreation

The department of physical education has supervision and control of the intramural sports and the recreational physical activities of the student body. The aim is to insure the health and physical development of every student.

Through its program in physical education and 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.

Prior to his or her arrival on campus, each new or transfer student must submit to the Health Service a record of physical examination filled in and signed by a physician, and a completed health history form. All such forms are carefully checked by the Health Service and each student thereby classified for activities in the department of physical education in accordance with his or her current health status.

The physical education program is voluntary, but all physically qualified students are required to take a swimming test. Tests are scheduled during the first week of the first semester.

A wide variety of instruction courses are available on a voluntary basis. Courses stress the history, rules, fundamentals and playing situations and are taught on an elective basis. Corecreation (for men and women simultaneously) opportunities are available. Instruction and competition for women students are available in a number of activities. Individual sports are offered on a voluntary basis.

In the gymnasium, opportunity is offered in the following activities: recreational swimming, beginners swimming, dance, physical development, boxing, fencing, apparatus exercises, life-saving, controlled weight training, badminton, judo, karate, and sports fundamentals.

A comprehensive program in intramural sports is sponsored for the student body including fraternity, residence hall, interclass, town, and independent groups in touch football, tennis, soccer, badminton, handball, individual athletics, basketball, swimming, wrestling, track, softball, squash, volleyball, and recreative games. Students are encouraged to participate in these sports, and awards are given for excellence in performance.

Individual exercises are prescribed for the correction of physical and functional defects. Students of this group are carefully examined and individually guided.

The university maintains a well-equipped Health Center for medical treatment. If a student is injured while engaged in any sport he must report as soon as possible to the first-aid room or to the Student Health Service.

Courses Open to All Lehigh Students

Nonswimmers
Basic Swimming
Senior Life Saving
Water Safety Instructors
Scuba Diving (fee)
Fencing
Field Archery
Target Archery
Bowling
Golf
Basic Tennis
Intermediate Tennis
Advanced Tennis
Modern Dance
Horsemanship (fee)
Physical Fitness
Personal Defense (fee)
Stunts and Tumbling
Basketball
Volleyball
Softball
Squash
Handball
Paddle Ball
Running
Skating (fee)
Skiing (fee)

No credit is given for these courses; they are voluntarily elected subject to permission of the instructor. A periodic announcement of class schedules is published.

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Special Academic Opportunities

An interdisciplinary tradition

Lehigh has traditionally taken advantage of its relatively small size and lack of rigid departmental lines to develop flexible and interdisciplinary programs. On the graduate level, a student may choose to pursue work by field rather than department in such areas as computer science, applied mathematics and management science (see Interdisciplinary Graduate Programs). The graduate student also may do a thesis or dissertation research in one of the eight interdisciplinary centers, which are described in the other gold section of this catalog.

Interdisciplinary work on the undergraduate level can be arranged in each of the colleges for the student desiring a concentration in a field outside a usual major.

The program in urban studies, outlined under Government in the description of courses, is intended to provide undergraduate instruction for students who wish to enter professional careers that require interdisciplinary knowledge of the problems of urban life or who will be pursuing graduate studies in urban affairs. Several cooperating departments, associated with the Center for Marine and Environmental Studies, provide instruction in marine ecology, biological oceanography, sanitary microbiology, water supply and transport, and environmental planning. Because environmental studies are interdisciplinary in nature, the emphasis in these courses is to provide a general introduction to the undergraduate planning graduate study in a specialized area.

In addition, there is the Social Welfare Education program, designed to provide semi-professional training in social work. The program is desirable for students interested in various areas of counseling and guidance work, the ministry and in urban planning. The program constitutes a minor of four courses taken in sequence at various Lehigh Valley colleges.

Student opportunities

Freshman Seminars

Interdisciplinary problem-centered Freshman Seminars (FS) are offered each semester to freshmen enrolled in any curriculum. A three-credit-hour seminar will serve as a general studies option in the engineering curriculum, a preliminary distribution elective in the arts and science curriculum, or an arts option or free elective in the business and economics curriculum.

The Freshman Seminars that are offered have been selected from those proposed by professors who have specified a transdisciplinary inquiry which they would like to pursue in seminar fashion with a group limited to fifteen freshmen. Such study gives each student experience in relating contemporary cultural problems to the many disciplines in the humanities and sciences. It also provides an opportunity to make initial exploration of one or more of those disciplines, thereby helping to season the student's judgment as to how his or her university education could best be structured.

Freshmen interested in enrolling in a Freshman Seminar are invited to use the application form that is part of the Freshman Seminar Ammouncement each semester, and which accompanies preregistration materials. After consultation with their faculty advisors, students submit these applications with other preregistration materials. The class roster for each Freshman Seminar is made up of students from each of the colleges. Beyond that basic restriction, selection of

students is made by random choice from among the applicants. Those who apply but are not chosen in the fall semester are given priority should they apply again in the spring semester.

Typical Freshman Seminars offered in recent semesters include: Science and Moral Values; Resources and the American Lifestyle; Change and Crisis in American Colleges; Man and His Man-Made World; The Revolt of the Inarticulate, and The Indian in America.

High Immediate Relevance Courses

A program of High Immediate Relevance (HIR) courses enables all instructional departments to introduce courses temporarily within a semester. HIR courses are normally either experimental courses or courses based on contemporary social and scientific issues. They may later become part of the regular curriculum if proven successful.

HIR courses can be taken on a pass/fail basis. Since most HIR courses are not developed in time to be included in this catalog listing, they are identified with a 97-98 number and are incorporated in the Registrar's official semester roster for a maximum of two semesters.

A sample listing of recent HIR courses includes: The American Presidency; Present and Future Energy for the World; The Black in American Literature; Electronic Music; Oral History; Contemporary Issues in Soviet Politics; Clinical Applications of Psychological Principles; and Ideologies and World Politics.

Change of major

There is a great flexibility in undergraduate curricula at Lehigh intended to take into consideration the changing interests and needs of students. For example, in the College of Engineering and Physical Sciences, each department provides a range of hours needed for graduation to provide flexibility to the student who wants to take more or less work outside the department. This flexibility extends to late changes of major or even a change in college without loss of credits.

Graduate students may find their interests shifting to new fields as they progress in their educational program or they may wish to strengthen their preparation for a career by advanced study in a related field or in an interdisciplinary program. The policy of the Graduate School is to provide as much flexibility as possible to students who wish to change to a new but related field of study after either the baccalaureate or the master's degree.

Students should consult with the director of their previous program and with the director of the new field in which they are interested to establish the course program that will remedy any deficiencies in background and will be of maximum value. Students who have just completed a bachelor's degree in one field at Lehigh University may find it advantageous to study for a graduate degree in a related field under a new group of the faculty without losing the continuity and familiarity provided by staying on the Lehigh campus.

Five-year, two-degree programs

Another feature of Lehigh's flexibility is the opportunity for five-year, two-degree programs which enable a student to receive either two bachelor degrees or a bachelor and a master's degree upon completion of five years of study.

Most five-year, two-degree programs appear in the description of courses under Arts-Engineering and Five-Year Programs. It is possible to arrange for a dual bachelor degree program even after studying at Lehigh for some period of 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 the bachelor of science degree may complete the combined requirements in five or possibly six years, depending on when they decide to try for both degrees.

Of increasing interest to undergraduates are the two-degree, five-year programs which enable one to secure a bachelor and a master's degree. Because Lehigh's well-established graduate programs are closely integrated with the undergraduate programs, it is possible to consider programs leading to the engineering-master of business administration degree, the arts-M.B.A. degree, the engineering-master of science in materials program, or the fifth-year program in the School of Education which enables those receiving a B.A. degree to accomplish professional teacher training and serve as salaried interns in the public schools. After the completion of one year of full-time teaching, students can receive the master of arts for secondary teachers or the master of education degree for elementary teachers. Many other five-year, graduate-

level combination programs exist, and students are advised to consult with their advisor in planning such programs.

Pre-law programs

Lehigh has a strong pre-law tradition. In keeping with the policy of the Association of American Law Schools, the University does not have any prescribed undergraduate pre-law program. Lehigh students have been successful in attaining entrance into law schools from diverse curricula within all three of the undergraduate colleges.

An active student-run Pre-Law Society brings members of the legal profession and law school personnel on campus for discussion meetings, and continuously provides information about law school opportunities.

Law-related courses, some of which rely on the casebook method, are provided by both the College of Arts and Science and the College of Business and Economics. 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 through members of the Pre-Law Advisory Committee, composed of faculty members of both colleges. Students are urged to consult members of the committee as early as possible in their academic careers.

Health professions programs

Schools of medicine, dentistry and veterinary medicine stress the importance of a broad general education as well as prescribed studies in the sciences. 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 faculty members from biology, chemistry, engineering and physics, provides information during freshman orientation to interested students and actively works with health-professions candidates from the sophomore year on to assist them in planning for entrance into professional schools in conjunction with their major advisors.

Lehigh affords two special baccalaureate-doctor of medicine degree programs for students interested in becoming physicians. These limited-enrollment programs are offered in association with two Philadelphia-based medical schools.

A bachelor of arts program in biology or a bachelor or science program in chemistry are available in connection with the Hahnemann Medical College. A bachelor of arts in biology program is associated with the Medical College of Pennsylvania. Descriptions of these accelerated courses of study may be found under Health Professions, listed with course descriptions found on subsequent pages.

Students interested in optometry, pharmacy, podiatry and other allied health fields may obtain information from the Health Professions Advisory Committee in planning their courses with their academic advisors.

Research initiates

Undergraduate students who seek or are considering a career involving research are encouraged to investigate the possibility of becoming research initiates in their junior or senior years. Research initiates are attached to specific research projects in progress on the campus, serving as assistants to advanced graduate students or to staff members. They assist in experiments, sit in on project conferences, and if occasion permits, undertake small side investigations appropriate to their competence.

The research initiate may receive degree credit by registering for unrostered work for up to six hours per semester. In a few cases, a nominal stipend may be paid for the work, and summer employment is also occasionally available. The student should explore the possibility of becoming a research initiate with the curriculum advisor.

Accelerated programs

It is possible for Lehigh students to accelerate their programs so that they may graduate in as little as three years. Such programs are made possible by credits awarded for advanced standing upon admission, credit by examination, overloads, and summer work. Again, interested students should consult with their curriculum advisors.

Special summer opportunities

In addition to the normal opportunities offered to graduate and undergraduate students in summer school, there are also opportunities for both remedial and accelerated work.

Special programs and field work activities are avail-

able for intense in-depth educational experiences. Examples of these include the Robert A. Taft Institute of Government, Field Study in Geology (conducted in Wyoming and Idaho) and the Civil Engineering Survey Field Course. Short courses and workshops are offered in a wide variety of subject areas.

Interested students should consult with their curriculum director or the Director of Summer Sessions. A Summer Session publication listing the total summer program is available in March of every year.

Apprentice teaching

Apprentice teaching is designed for advanced students, normally in their senior year, who wish to learn about teaching under the guidance of an experienced teacher. Master and apprentice teachers are, with the approval of the chairman of the department in which the apprentice teaching is done, free for the most part to work out whatever arrangements best fit the needs of the course.

Apprentices typically receive three hours of credit for attending all classes, doing some lecturing or leading of discussion sections, assisting in making up and grading some written assignments and tests, and being available for some individual consultation with students.

A student may register for apprentice teaching only once each semester, and only twice (for credit) in the college career, for a maximum total of six hours of credit. The student may be an apprentice teacher (for credit) in a given course only once. A graduate student who is not a paid teaching assistant may register for apprentice teaching, but the department must decide whether the credit received for the course will count toward fulfilling course requirements for a graduate degree. The apprentice will be graded by a master teacher. Students who wish to do apprentice teaching in extra-departmental courses, such as those offered as Freshman Seminars or Creative Concepts courses, may do so with the approval of the director of the program. Such students will be registered for course number 300 in the appropriate program (e.g., F.S. 300: Apprentice Teaching in F.S. 97C; or C.C. 300: Apprentice Teaching in C.C. 101). Course listings in this catalog, however, simply list "300: Apprentice Teaching," with the course to be taught left unspecified.

Study in foreign countries

To the extent that their courses of study permit it, students maintaining a "B" average or better are encouraged to consider spending one or two semesters of study in acceptable "junior year abroad" programs or as regularly enrolled students in a foreign university. Among the accepted programs are New York University in Spain, Smith College and Wayne State University in Germany, Sweet Briar and Hamilton in France, and Dickinson College at Bologna, Italy. Students declared qualified for acceptable foreign study remain eligible to apply for financial aid from Lehigh University.

To emphasize further its interest in international study, the University has provided funds to cover transportation, tuition, and living expense stipend for a graduating senior desiring to study abroad.

The modern foreign languages department offers, subject to annual approval by the administration, a second-semester program in academic subjects at a German university with Lehigh credit. The program is open to students with junior standing or above.

The Harrisburg Urban Semester

Undergraduates from all parts of the University can spend either the fall term or the spring term in Pennsylvania's capital city of Harrisburg to study urban problems. They live and work with students from other participating Pennsylvania colleges and are supervised by The Harrisburg Urban Semester (THUS) faculty or its member college faculty.

The curriculum consists of three basic parts: internship, independent study and an urban seminar. Internships, which are the core of the program, are available in federal, state, county, city, private and religious organizations. They range from environmental protection, prison and probation, drug rehabilitation, day care, state legislature, mental health, city planning, public works, legal services, and community organization. Students in all fields of study are encouraged to participate. Upon completion of the semester, students receive sixteen semester hours of credit.

The Washington Semester

Opportunity is available each year for several selected juniors or seniors to spend one semester of study in the nation's capital through cooperation with Ameri-

can University in Washington, D.C., and some sixty other colleges and universities.

The students enroll at Lehigh but spend the semester in residence at American University with the students from the participating colleges. Should a student withdraw from either the Washington or Harrisburg program, the student will be held responsible for the costs incurred through the program. These costs will be calculated on the basis of the University's customary refund policy.

Afro-American studies

The University offers a number of courses that are relevant to Afro-American studies. Representative courses are S.R. 368, Urban Community; Hist. 331, The Negro in America; Govt. 352, Civil Rights; and Engl. 345, Themes in American Literature. Students who are interested in Afro-American studies work out an interdisciplinary major with their advisors or with the dean of their college.

Cooperative college program

Lehigh University is a member of the Lehigh Valley Association of Independent Colleges (LVAIC). This consortium also includes Allentown College of St. Francis de Sales in Center Valley, Cedar Crest and Muhlenberg colleges in Allentown, Moravian College in Bethlehem, and Lafayette College in Easton.

Under an agreement among the colleges of LVAIC, students on one campus may cross-register for courses given on another campus. Students desiring to take advantage of this opportunity must obtain the consent of the course instructors and advisors concerned and accept differences in calendar and course scheduling. They must provide their own transportation. A student taking a course on another campus under this arrangement does not pay extra tuition for the privilege, and the course he or she takes and the grade assigned in it are recorded on the transcript of the home institution. The agreement applies only to undergraduate students and extends to both the academic year and summer sessions.

A cooperative Social Welfare Education Program designed to provide preparation for entrance-level professional competence in social welfare positions is sponsored by LVAIC. Lehigh students wishing to participate in this program should consult with the chairman of the department of social relations.

Comprehensive Honors Program

The Comprehensive Honors Program is designed to permit students who demonstrate unusual academic ability and interest to explore more widely than their curricula would normally allow and to engage in independent study and research.

Freshman-sophomore years. These are the years in which a student normally chooses the major field of study and lays the required groundwork for it. Thus, honors opportunities are limited.

Honors opportunities for freshmen consist of assignment before registration of those most qualified to honors courses in place of certain required freshman courses, and acceleration through the attainment of advanced standing. Advanced standing may be certified by the Office of Admission and the registrar on the basis of college credit granted for certain special secondary school courses. Generally, however, students who seek advanced standing should arrange to take the relevant tests under the CEEB Advanced Placement Program.

There are no specific sophomore honors opportunities. However, second-semester freshmen and all sophomores who wish to accelerate their programs may seek waiver of the junior-standing prerequisite for courses numbered "100" to "399," if they have the course prerequisites. Students interested in so doing should consult the dean of their college.

Any undergraduate may accelerate an academic program by passing a special examination in any course the student feels has been mastered. Interested students should consult with the chairman of the department indicated.

Junior-senior years. Honor students are those with a cumulative average of 3.0 or higher. In the first or second semester of the junior year, an honor student may choose to work for Departmental Honors. An honor student enrolled in this program is designated a "University Scholar." Students with cumulative averages of less than 3.0 may under some circumstances be permitted to work for Departmental Honors.

Departmental Honors

These programs give the University Scholar the opportunity to study in the major field more intensively and in greater depth than the standard program provides. The precise nature of the program for each student is determined by the major department. The

program may include:

a) Unscheduled work or independent study (up to four hours per semester in the junior year; up to six hours per semester in the senior year).

b) Waiver of graduate standing: undergraduate students will be permitted by petition to the Graduate School to register in a 400 course for which they have the necessary prerequisites under the conditions that they: (1) have maintained a 3.00 average in each of the two semesters prior to the date of the petition, and (2) will carry a course load not to exceed 15 hours unless four-credit courses, military science or aerospace studies and the like, raise it to 17 hours maximum.

c) Honors thesis or project.

Candidates for Departmental Honors must announce to their major advisor during the junior year, or no later than the beginning of the senior year, their intention to work for Departmental Honors. Each major advisor must submit to the registrar, the dean of the college, and the chairman of Honors Programs, no later than the close of registration of each fall semester, the names of seniors who are working for Departmental Honors in the particular major. The names of those students who attain Departmental Honors will be announced at the graduation exercises.

College Scholar Program

The College Scholar Program offers the qualified student a unique opportunity for maximum enhancement of critical faculties, abilities and intellectual interests. This end is achieved through a structured program conforming to exceptional standards of breadth and rigor.

Undergraduate students in the College of Arts and Science may apply for acceptance into the program at any time during their college careers. An application is made to the Honors Committee, and acceptance is governed by the performance of the student to date and the committee's estimate of the likelihood that he or she will be able to fulfill the requirements of the program. In order to be graduated with the designation "College Scholar," a student must fulfill the requirements and achieve a cumulative average of 3.50.

Each student is required to have an individually structured program which must be approved by the Honors Committee. All changes in such a program are subject to review by this same committee. No course taken pass/fail may be used to satisfy the requirements. The requirements follow.

Area of concentration

The major. Departmental or interdepartmental. The academic level expected of candidates in the area of concentration can be attained by satisfactory completion of courses such as those at the 400 level, independent study, etc.

Thesis. The student takes a certain number of hours in independent study or thesis courses, culminating in a thesis or research report. This is read and rated by an ad hoc committee of three faculty, one of whom must be from outside the department or departments in which the student is doing major work.

Comprehensive. There is to be a comprehensive examination in the area of concentration; it may be written, oral or both. A committee in charge of the examination includes at least one person from a department other than that (or those) in which the student is doing major work.

Distribution Requirements

English. English 1 and either 2, or 10, 14, 16.

Language. Proficiency in a classical or modern foreign language sufficient to complete the work of the fifth semester in any 3-3-3-3-3 language sequence; in a 5-5-4 sequence, completion of the third semester is required. There is no restriction on the languages acceptable.

Mathematics. One course from the following: Math. 21, 31 or 41.

Natural Science. Four courses chosen from two of the following areas: astronomy, biology, chemistry, geology, physics and psychology. At least one of these courses shall be in chemistry or physics, and at least one of the four courses shall include the accompanying laboratory course.

Social Science. Four courses chosen from the areas of archaeology, economics, government, history, international relations, psychology, social relations and urban studies. At least one of these courses must be in economics and one in history.

Humanities. Four courses chosen from the areas of drama, fine arts, literature (English and advanced courses in classical and modern foreign languages), music, philosophy and religion studies. At least one of these courses must be in philosophy or religion studies, one on literature, and one in the creative

arts (drama, music and fine arts).

Note: Each of the last three requirements is stated in terms of *areas,* not *departments,* in recognition of the fact that not all humanities courses are offered in the departments whose names appear under "Humanities," not all historical courses are offered by the history department, not all philosophical courses by the philosophy department, etc. The committee makes the decision, in consultation with the appropriate departments, under which rubric a specific course may be counted. It also is empowered to admit what substitutions it deems wise.

Honors seminars

Two seminars, normally to be taken during the sophomore or junior year. A study of major ideas which have dominated Western thought.

Electives.

Humanities Perspectives on Technology program

Lehigh's Humanities Perspectives on Technology (HPT) program involves the study of the effects of science and technology on the quality of human life and those values which traditionally are the concern of the humanities. The program is based in the College of Arts and Science but fosters interdisciplinary cooperation with faculties of the other colleges in the university. Students from each of the three undergraduate colleges are actively sought as participants.

The minor. The program offers a minor in Technology and Human Values, which may also count as a "Course Concentration" in General Studies for students in the College of Engineering and Physical Sciences. Fifteen hours of work in courses sponsored by the program are required. Of these, a course in the History of Technology (such as History 5 or History 6) and the course HPT 97 are required. The remaining courses must be distributed among the various departments offering courses sponsored by the program as determined by the director of the program in consultation with the students.

Courses

HPT 97	Humanistic Perspectives in a Technological Society
Engl/Phil 150	Media and Values
Engl 149	Science Fiction
Engl 351	Experimental Literature
Lat 204	The Ancient City
Hist 5	The Machine in America
Hist 6	The Machine in Modern America
Hist 341	The Development of Federal Science Policy
Hist 342	The American Engineer
I.R. 41	Science, Technology and International Relations
I.S. 11, 12	Computer Programming and Applications in the Humanities and Social Sciences
Mus 198	Electronic Music
Psych 312	Psychology of Work and Leisure
Psych 210	Futuristics
Phil 100	Philosophy of Contemporary Civilization
S.R. 203	Social Ecology

The program is constantly developing new courses. Bulletins announcing and describing them are published regularly. For further information, consult the College of Arts and Science office.

Presidential Prizes

Lehigh University offers each year ten Presidential Prizes valued at $4,000 each, for four years of college. These are reserved for entering freshmen and are awarded on a competitive basis, irrespective of financial need. Each prize provides $500 per semester, credited toward tuition, in any of the three undergraduate colleges of the University.

The prizes, once assigned, continue in force for the full four years of the student's residence at Lehigh University, unless the holder fails to meet the normal scholastic requirement of a 3.00 average or better and the qualifications of a good citizen. In rare instances this requirement may be waived upon unanimous vote of the prize committee and the approval of the president. The prize is based strictly on merit, without regard to financial need.

In order to compete for one of the prizes a freshman candidate must:

(1) Be a successful candidate for admission in any of the three undergraduate colleges, Arts and Science, Business and Economics, or Engineering and Physical Sciences, with evidence of promise of high academic achievement.

(2) Submit a separate prize application providing more detailed information regarding any important piece of creative work, independent study, evidence

of leadership potential, notable accomplishments which do not appear on the regular record submitted for admission, or the promise of making an extraordinary contribution to the life of Lehigh. Thus the applicant may show high achievement in such diverse areas as the arts, the sciences, athletics, original scholarship, literature, or music.

(3) Be interviewed by a member of the Lehigh faculty, generally a member of the prize committee. If distance prohibits a campus visit, the interview may be with a selected alumnus or alumna.

All candidates for admission are automatically eligible to compete for one of these prizes and will be so considered. A preliminary selection of finalists is made in January when prize applications are distributed and interviews conducted. Winners are announced in April. It is possible to receive a Presidential Prize and also qualify for other forms of financial aid. The Parent's Confidential Statement, however, is not required to be considered for a prize.

Prizes will be made in the order of the contestants' ratings on such weighted factors as secondary school scholastic record, evidences of effective leadership and distinguished group service, character and personality, and performance in the College Entrance Examination Board tests. The prizes follow the general plan of the prestigious academic scholarships typified by the Rhodes Scholarships. Geographic location will play some part in the final selection. Men and women students are equally eligible.

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College of Arts and Science

John W. Hunt, *Dean*
G. Mark Ellis, *Associate Dean*

The Curricula

The College of Arts and Science offers several curricula options: (a) a four-year curriculum in arts and sciences, leading to the degree of Bachelor of Arts; (b) four-year curricula in the fields of biology, geological sciences, psychology, and environmental sciences and resource management, leading to the degree of Bachelor of Science in the designated field; and (c) a five-year curriculum in Arts-Engineering leading to a baccalaureate degree from the College of Arts and Science and a B.S. degree in the student's field of engineering.

Freshman English

Students in all of these curricula must meet a requirement for freshman English. The normal requirement is English 1 and 2, 10, 14, or 16. For exceptions, see Advanced Placement.

Bachelor of Arts degree

The curriculum in Arts and Science emphasizes a liberal education. It asks the student, in collaboration with his or her advisor, to select courses to fill three general categories, namely, distribution to insure breadth of education, a major field of concentration to provide depth, and free electives to adjust both breadth and depth to the student's individual needs.

Distribution Requirements

The objective of the distribution requirements is to give the student an elementary knowledge of the fields of contemporary thought and to orient the student to the world of man and nature. The requirements also provide opportunities for students to take additional work in fields related to their major field of concentration. In addition, the preliminary requirements give students experience with each of the college's three distribution areas before a major field of concentration must be chosen.

Distribution requirements are administered by the Dean of the College of Arts and Science in accordance with the group regulations given below. The student has a wide choice of offerings from which to select courses to fulfill distribution requirements and will have an opportunity to discuss these with his or her faculty advisor prior to preregistration each semester.

There are two types of distribution requirements: preliminary and upperclass.

Preliminary requirements. These should normally be fulfilled by the end of the student's fourth semester of college work. However, when a student's academic

program permits it, they should be completed by the end of the third semester. With the exception of courses in mathematics, science, and modern and classical languages, which may be used for either preliminary or upperclass requirements based on the student's progress in the discipline, preliminary courses are indicated by a (P) following the title.

At least one course is chosen from each of two subcategories in each of the three distribution areas listed below:

A. Classical and Modern Foreign Languages
B. Literature (courses in English or American Literature; Greek, Latin, or modern foreign literature in translation; or foreign literature courses at the third-year level or higher not involving conversation and composition)
C. Philosophy
D. Arts (Music, Drama, Fine Arts)
E. Religion Studies

Area II Social Sciences
A. Government, International Relations
B. Social Relations, Psychology courses designated SS (Social Science)
C. History (including Ancient History) and Archaeology
D. Economics
E. Urban Studies

Area III Mathematics and Science
A. Mathematics, Astronomy and Logic
B. Biology
C. Chemistry
D. Geological Sciences
E. Physics
F. Psychology courses designated NS (Natural Science)

Upperclass requirements. To ensure intellectual breadth in the student's progress towards the Bachelor of Arts degree, a student must fulfill upperclass distribution requirements, normally after the major field has been selected. These consist of twenty hours elected by the student in courses above the elementary level in the two above-listed distribution areas other than the one which includes the student's major. In the case of mathematics, science and foreign language courses, all course levels may be used to meet the upperclass requirements.

It is expected that each student will fulfill the distribution requirements in a manner that will satisfy the student's intellectual goals and needs as student and advisor perceive them. A student's program, including the choice of distribution requirements, is not official until approved by the student's advisor.

Language opportunities

The study of a foreign language is not required for either the B.A. or B.S. degree in the College of Arts and Science. However, students in the college are strongly urged to begin or continue the study of foreign languages and cultures by registering for courses offered by the departments of modern foreign languages or classics. Students who are qualified are also encouraged to participate in approved Study Abroad programs regardless of their major.

The principal purpose of foreign language study is to develop means of perceiving and understanding a culture other than one's own. The ability to use a foreign language enables the student to communicate with those who are part of a foreign culture. Furthermore, in acquiring such ability, the student sharpens his knowledge and use of the English language.

Students who are planning on graduate study toward the Ph.D. are reminded that most graduate schools require Ph.D. candidates to demonstrate a reading knowledge of one or two foreign languages. Many careers in commerce, industry, and the federal government likewise require ability to use a foreign language.

Major field of concentration

By the end of the sophomore year, each student in the curriculum of Arts and Science will select some sequence of studies as a major field of concentration. A major consists of at least twelve hours of advanced work in the field chosen. Including preliminary college work, the minimum number of hours constituting a major is twenty-four.

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. In all fields certain courses are prescribed, but the mere passing of courses will not satisfy the major requirements. A student must achieve a minimum 2.0 average in his or her major courses.

Standard major sequences

The student may wish to choose one of the standard major sequences. See the appropriate alphabetical listing under Description of Courses.

When a student selects one of these standard majors, the chairman of the department offering the major or the official director of a nondepartmental major becomes a student's major advisor and makes out the student's major program. The final responsibility for meeting both major and non-major requirements, however, rests with the student.

Special interdisciplinary majors

In addition to the standard major programs, specially structured interdisciplinary major sequences are possible. For example, a student interested in a professional school of urban or regional planning might be interested in structuring a special major consisting primarily of courses in government and economics, or of economics and social relations.

Any student may, with the aid of members of the faculty chosen from the disciplines involved, work out an interdisciplinary major program to include not less than twenty-four hours of related course work, of which at least twelve hours shall consist of advanced courses. The program must be approved by the major advisors 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 advisors. 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 administrative major for preregistration purposes but is expected to maintain normal progress in fulfilling the requirements in both.

Bachelor of Science degree

Students desiring to major in the fields of biology, geological sciences, psychology, or environmental sciences and resource management may elect to work for a Bachelor of Science degree. This option is also open to Arts-Engineers desiring to major in one of these fields.

Normally, a student electing to work for the B.S. degree will have a strong pre-professional orientation. He or she will take more courses in the major field of concentration than will a student in the Bachelor of Arts program. In all other respects the student in a B.S. curriculum will meet the same requirements as will the student in the Bachelor of Arts program, except that the B.S. candidate is not asked to fulfill the same distribution requirements.

For the specific requirements of the B.S. curricula in biology, geological sciences, psychology, and environmental sciences and resource management, please see the Description of Courses section.

Arts-Engineering option

The curriculum in Arts-Engineering is especially designed for students wishing a regular professional education in a field of engineering and also the opportunity to study broadly or in 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 B.A. or B.S. major program. In normal circumstances the student will complete work for a degree in the College of Arts and Science at the end of four years. The student transfers for the fifth year to the appropriate department of engineering, where he or she pursues a regular fourth year of science and engineering course work in the chosen field of engineering.

These arrangements make it difficult for an Arts-Engineer to qualify for the B.S. in the College of Engineering and Physical Sciences before meeting all requirements for the baccalaureate in the College of Arts and Science. In some instances it may be advisable to take the two degrees at the end of the fifth year. To qualify for both degrees a student must submit for the second degree thirty credit hours in addition to the number required for the B.S. in engineering alone.

Arts-Engineers working for the baccalaureate of arts automatically fulfill the engineering general studies requirements while filling the distribution requirements of the College of Arts and Science. Arts-Engineers working towards the Bachelor of Science in biology, geological sciences, psychology, or environ-

mental sciences and resource management must pay special attention to the engineering general studies requirements, which must be met in time for the student to qualify for the Bachelor of Science degree in engineering.

Arts-Engineers have the same opportunities for multiple majors and special interdisciplinary majors as are available to students working for the baccalaureate in the college.

Pattern rosters which show the normal combination of courses for the first four years of the Arts-Engineering curriculum will be found under Arts-Engineering.

Graduation requirements

The Bachelor of Arts degree

1. The completion with the required average of a minimum of 120 credit hours of collegiate work, apportioned so as to cover the distribution and concentration requirements. Basic courses in military science or aerospace studies are carried in addition. No more than six hours of advanced aerospace studies or military science may be counted towards graduation credit.
2. A cumulative average of 2.00 or better in the courses required in the student's major program.
3. Completion of all general requirements applying to all candidates for baccalaureate degrees.

The Bachelor of Science degree in biology, geological sciences, psychology, or environmental sciences and resource management

1. The completion with the required average of the minimum number of credit hours of collegiate work indicated for the curriculum. Basic courses in aerospace studies or military science are carried in addition. No more than six hours of advanced military science or aerospace studies credit may be counted towards graduation credit.
2. Completion of all general requirements applying to all candidates for baccalaureate degrees.

Special Requirements

Regular progress. Each student in the college is expected to maintain regular progress towards the baccalaureate degree by carrying a normal course load each semester. The normal course load may vary between fourteen and seventeen hours depending on the number and difficulty of the courses involved. Courses in military science or aerospace studies are usually carried in addition. Normal semester course loads for Arts-Engineering students are detailed in the pattern rosters for Arts-Engineering.

Senior essay or comprehensive examination. Students majoring in international relations must write a senior essay. In the case of classics and foreign careers majors, a comprehensive examination is required.

Special opportunities

Minor program in the college

Certain departments, divisions and programs in the college offer an opportunity to minor in an additional field of concentration other than the discipline which the student chooses for the major field of concentration. Such a minor consists of at least fifteen hours, the specific content of which 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.

If a minor program is not listed under the department desired, the student should consult the department head.

Students will declare a minor through their major advisors, who will keep the records concerning it; but it shall be the student's responsibility to initiate it and seek any necessary advice in the department, division, or program offering it.

The minors from College of Arts and Science departments and programs are available for degrees in other colleges within the University at their option.

Fundamentals of Business minor

In cooperation with the College of Business and Economics, students in the College of Arts and Science may elect a special Fundamentals of Business minor consisting of the following courses:

Required background courses:

Eco 1	Economics (4 credit hours)
Math 41	BMSS Calculus (3)
Math 44	BMSS Calculus (3)
Eco 45	Statistical Method (3)

Acctg 51	Essentials of Accounting or
Acctg 108	Fundamentals of Accounting (3)
Eco 206	Microeconomic Analysis (3)

Required functional areas:

Mgt 269	Management of Operations in Organizations (3)
Mkt 211	American Marketing System (3)
Fin 225	Business Finance (3)

Electives (three courses from among the following):

Acctg 52	Essentials of Accounting (3)
Acctg 111	Computers in Business (3)
Law 101	Business Law (3)
Mgt 270	Conceptual Foundations of Organizational Theory and Behavior (3)
Eco 129	Money and Banking (3)
Eco 219	Macroeconomic Analysis (3)

No student selecting the Fundamentals of Business minor may take more than 25 percent of total university course work in business courses (i.e., in finance, accounting, management and law). Interested students should consult the dean's office in the college.

Technology and Human Values minor

The Humanities Perspectives on Technology program offers a minor in Technology and Human Values involving 15 hours of work in courses in an interdisciplinary program. Details are listed under Special Academic Opportunities, page 39.

Arts-M.B.A. program

This five-year, two-degree program is designed to meet the needs of competent students in any of the Arts and Science majors who wish to supplement their liberal education with graduate training in business management.

The normal over-all time involved in the two-degree program is five years. During the first four years the student takes background courses in business and economics. When the student successfully completes these and is admitted to the graduate phase of the program, he or she may expect to complete remaining requirements for the Master of Business Administration degree in one additional year.

The background courses to be taken during the undergraduate years will be found listed under the M.B.A. degree section of the College of Business and Economics, page 49.

Lehigh-Hahnemann M.D. program

The Hahnemann Medical College and Hospital, in Philadelphia, has established a cooperative program in primary-care medicine with Lehigh University. The program enables ten selected students to earn the B.A. degree in biology and the M.D. degree from Hahnemann after six years of study. Special preference will be given to well-qualified students from the Lehigh Valley and Eastern Pennsylvania with a strong inclination towards family practice medicine. Further details of the B.A. biology program are described under Health Professions (see Course Descriptions).

Lehigh-Medical College of Pa. M.D. program

Lehigh University and the Medical College of Pennsylvania, in Philadelphia, have established a joint educational program which enables selected students, approximately fifteen each year, to earn the B.A. degree in biology and M.D. degree after six years of study at the two institutions. Further details of the B.A. biology program are listed under Health Professions (see Course Descriptions).

Honors and the College Scholar program

Qualified students in all curricula of the college may choose to work for either departmental honors or the College Scholar program. Details of departmental honors and the College Scholar program are given under Special Academic Opportunities.

Independent Study

Students will find various opportunities for independent study in all curricula and most major sequences. They work out such programs of independent study in collaboration with their major advisors. On the advice of the chairman of the student's major department, and with the consent of the dean of the college, juniors or seniors of unusual merit who wish to concentrate in their chosen field may be allowed to substitute no more than four or six hours respectively of unscheduled work per semester for an equal number of hours of elective work otherwise required for graduation.

Acceleration

Opportunities for students to accelerate towards graduation include, in addition to advanced placement

and work in summer school, rostering course overloads during the regular semester and passing special examinations for credit. Students should see their major advisor or the dean of the college concerning these opportunities.

College of Business and Economics

Brian G. Brockway, *Dean*
Max D. Snider, *Associate Dean*

Programs of study

The College of Business and Economics, which is a member of the American Assembly of Collegiate Schools of Business, offers a program of study designed to provide an understanding of the complexities of the managerial process in society, both within and outside the business firm. Many of the most difficult societal problems today involve decision-making, conflict resolution, and the efficient and effective management of human and physical resources. Studies of business and economics provide fundamental bases for understanding and approaching solutions to many aspects of these problems, particularly as they present themselves to business leaders and administrators in other fields.

Thus the college's undergraduate business program stresses analytical and communication skills for the development and articulation of problem-solving techniques. Educational breadth is provided, equivalent to many liberal arts programs, but with depth of study of business processes such as accounting information systems, financial flows and markets, management processes and the impact of economic variables and forces upon business and social issues. In essence, the undergraduate education deemed most suitable for young men and women who will be the business leaders of tomorrow is formulated as analytically rigorous but with broad educational foundations combined with an exercise in depth of understanding of business processes in the economy in which we live.

This education in fundamentals, principles, and problem-solving mental agility provides the graduates with various options. Some of the young men and women 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 go into teaching of economics or administrative science. Undergraduate education must first of all provide the solid base of analytical skills and acquaintance with a segment of significant and relevant phenomena of our society. Equipped then with learning skills and intellectual facility in problem solving, the student's ultimate career must be of his or her own making.

Business today can no longer be approached with narrow or superficial vocational training. Its problems are strongly conditioned by the state of the economy and even by social issues confronting modern business executives. Thus a strong basis in the social sciences is essential to understanding the nature of business organizations. The student must also touch base 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 Lehigh's undergraduate program in business and economics.

At the same time the student of today must be provided with options. Initiative and motivation would be stultified in a straight-jacketed curriculum. To avoid such rigidity, the necessary exposures to science, language, and other arts are accomplished by optional requirements, within each of which the student has wide choice. Thus the basic curriculum rationale is similar to a distribution requirement in liberal arts, to guarantee breadth of undergraduate educational experience. Additionally, however, approximately twenty credits required for graduation are completely open for selection on a free elective basis. Thus some students take double majors, since intensive specialization is not required, others carry majors into more advanced levels, while still others choose work across the University ranging from humanities to technical engineering subjects, achieving even greater breadth or more specially tailored combinations than provided in standard requirements.

Thus the degree of Bachelor of Science in Business and Economics represents a liberal educational experience coupled with acquiring an understanding of business and the economy. It may lead directly to a fifth-year achievement of the Master of Business Administration degree in the college or at some other institution.

Goals of the college

Objectives of the College of Business and Economics are to provide an understanding (at the undergraduate level) and managerial and/or research-teaching expertise (at graduate levels) of the nature of business enterprise decision-making and resource management in the economy. Undergraduate objectives may be summarized as follows:

1. To provide tools of analytical rigor and perspective for continuing learning abilities with respect to the nature of business and its role in the economy;
2. To increase communication skills;
3. To provide breadth of appreciation of the scientific, technological, social science and humanity features of the world in which business is carried on;
4. Through a common body of knowledge to stimulate interest in and acquaint a student with basic business and economic systems of pricing, financial accounting, distribution and management processes;
5. Through a major, to provide each student with a learning exercise in depth in at least one area of business or the economy in which business operates such as accounting systems, finance, economics, economic statistics, foreign careers, management or marketing.
6. To work increasingly with mature students for intermediate and upperclass subject areas of business and economics, as an introduction to professional work or a sound basis for acquiring experience in the field or for graduate education.

Graduate programs leading to the degrees of Master of Business Administration, Master of Arts and Master of Science as well as the Ph.D. and Doctor of Arts degrees are described on following pages.

B.S. in Business curriculum

To obtain the bachelor of science degree in business and economics, 120 credit hours are required.

College Core Requirements (55 credits)

English and Mathematics (12 credits)

Engl 1	Composition and Literature (3)
Engl 2, 10, 14, or 16	Composition and Literature (3)
Math 41	BMSS Calculus I (3)
Math 44	BMSS Calculus (3)

Business and Economics Core (43 credits)

Eco 1	Economics (4)

Eco 45	Statistical Method (3)
Eco 129	Money and Banking (3)
Eco 206	Microeconomic Analysis (3)
Eco 219	Macroeconomic Analysis (3)
Acctg 51	Essentials of Accounting (3)
Acctg 52	Essentials of Accounting (3)
Acctg 111	Computers in Business (3)
Law 101	Business Law (3)
Mkt 211	American Marketing System (3)
Fin 225	Business Finance (3)
Mgt 269	Management of Operations in Organizations (3)
Mgt 270	Conceptual Foundations of Organizational Theory and Behavior (3)
Mgt 301	Business Management Policies or
Eco 333	Managerial Economics (3)

Note: BMSS stands for biological, management and social science.

Major program (15 credits)

Before the end of the first semester of the junior year, students select a major or field of concentration. A major program consists of sequential or related courses in accordance with one of the designated major programs, as detailed on following pages under department course listings. Five majors are offered: accounting, economics, finance, management, and marketing.

Optional courses (30 credits)

The student must elect three hours of courses from each of the following four groups:

(1) English, speech, journalism or modern foreign language departments.

(2) Government, history, international relations, and social relations departments (including the Division of Urban Studies).

(3) Fine arts, classics, mathematics, music, religion studies, and philosophy departments.

(4) Biology, chemistry, geological sciences, physics and psychology departments.

The remaining hours (18) must be taken in any one or more of the departments listed in the four groups above or any one or more of the departments in the College of Arts and Science, as follows: biology, classics, English, fine arts, geological sciences, government, history, international relations, mathematics, modern foreign languages, music, philosophy, psychology, religion studies, and social relations. One-hour courses will not be accepted for the optional courses but may be counted toward electives.

Electives (20 credits)

Normally, any courses in the University for which a student has the prerequisites may be used as electives as long as such courses carry University credits. Advanced military science and aerospace studies courses may be counted as electives up to six credits, but freshman and sophomore level courses in military science and aerospace studies do not carry credit against the 120 hours required for graduation.

Planning courses of study

In addition to freshman English and mathematics requirements, each freshman enrolled in the College of Business and Economics registers for Economics 1 in the freshman year. For the fourth and possibly fifth courses, the student takes courses toward the optional requirement each semester of the freshman year. The normal program for freshmen is fifteen hours each semester.

Accounting 51 is taken in the first semester of the sophomore year. Other business and economics core requirements should be selected with some sampling of introductory courses that may help the student choose the major in the junior year.

The pass-fail option is available for students in the college for elective credits. Courses with passing letter grades must be submitted to meet the core, major program, and optional requirements. Courses taken on a pass-fail basis will be classified as elective courses.

The senior year's work must be taken in residence.

Graduate study in business and economics

The College of Business and Economics offers three degrees at the master's level: the M.B.A., the M.A. and M.S. On a more advanced level, the college offers the Ph.D. and Doctor of Arts degrees.

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.A.-M.S. programs.

A candidate for admission to graduate study in the College of Business and Economics must offer either the Admission Test for Graduate Study in Business (ATGSB) or the Graduate Record Examination (GRE) Aptitude Tests.

The M.B.A. degree

The Master of Business Administration degree is designed to give candidates conceptual, analytical, and operational knowledge of decision-making processes in the management of human and physical resources. Both internal and external aspects of enterprise and organizations in modern economic systems impinge upon managerial roles. Education in the business professions requires understanding of business functions but also integration of these in the management process. The program requires generalized managerial competence but permits, if the student desires, advanced concentration in such fields as finance, marketing, quantitative or behavioral management, professional accountancy or economics, international trade and finance, labor relations, etc.

All candidates for this program are required to take the Admission Test for Graduate Study in Business. Information about this test may be obtained at many counseling centers or by writing to the Educational Testing Service, Box 966, Princeton, New Jersey 08540.

The courses listed below are available in the evening or on Saturday morning to permit qualified candidates to obtain the degree on a part-time basis. Ordinarily graduates of a four-year program in business and economics complete the M.B.A. in one year on a full-time basis. Normally, two years on a full-time basis are required to complete the M.B.A. degree for those candidates who have not previously completed any of the first-year program courses listed below.

First-year program (30 hours)

Quantitative Methods and Systems

Acctg 51	Essentials of Accounting or
Acctg 108	Fundamentals of Accounting (3)
Acctg 111	Computers in Business (3)
Eco 45	Statistical Methods (3)
Mgt 269	Management of Operations in Organizations (3)

Functional and Organization Studies

Fin 225	Business Finance (3)
Mkt 211	Marketing (3)
Mgt 270	Conceptual Foundations of Organizational Theory and Behavior (3)

Economic and Legal Environment

Eco 129	Money and Banking (3)
Eco 206	Microeconomic Analysis (3)
Law 101	Business Law (3)

Note: Students who have had Acctg. 51 and 52 or the equivalent are not required to take Acctg. 108.

Students are usually given credit without examination for one of the foregoing courses with grades of C or better if taken toward a prior degree earned not more than eight years before first matriculation in the M.B.A. program.

Required advanced courses (15 hours)

Acctg 422	Managerial Accounting (3)
Eco 431	Managerial Economics or
Eco 432	Advanced Microeconomic Analysis (3)
Fin 421	Financial Management (3)
Law 401	Legal Problems in Business (3)
Mgt 451	Managerial Policy and Decision-Making (3)

Note: Students who majored in accounting substitute Acctg. 431, Accounting Theory and Thought, for Acctg. 422.

Mgt. 451 should be taken the last semester before graduation.

Elective courses (15 hours)

Elective credit hours may be selected from desired combinations of 300- and 400-level courses offered in the College of Business and Economics, as described under the various departmental listings.

Of the total of 60 credits, the last 30 credits are taken in residence and must meet the University graduation requirements for any master's degree. At least one 400-level elective course is required.

Graduate work for research and/or teaching

The Ph.D. degree

The philosophy of the Ph.D. program is to nurture the individual's intellectual growth so that he or she may independently pursue professional objectives. It

is assumed that the individual's level of proficiency, attained at the completion of the degree program, will continue to increase with professional development.

The student is expected to pursue an intellectual and scholarly interest in four areas, including economic theory. The program of study in these four areas is arranged with the chairman of the doctoral committee of the college. This program of study is designed to prepare the student to pass general examinations in the four areas so that he or she may be admitted to candidacy. Course requirements include competence in quantitative analysis at least through Economics 352, Advanced Statistical Methods (3), and Management 302, Quantitative Methods–Conceptual (3), and a course in the history of economic thought. Once the student has satisfactorily completed the general examination, a dissertation committee is organized and its chairman guides the candidate in the preparation of his or her dissertation.

The Doctor of Arts degree

The philosophy of the Doctor of Arts degree is to provide advanced graduate work with breadth of knowledge, sensitivity and teaching skills in preparation of teaching faculty particularly for two-year and four-year colleges. A sensitivity core of 12 hours is required. Additional classwork of at least 36 hours (of which 24 must be at the 400 level) is required in preparation for doctoral examinations in four fields (of which one may be outside the college) including an examination in economic theory. Additional requirements include an internship and research project dealing with learning, teaching, or research problems in business or economics.

The Master of Arts and the Master of Science degrees

The Master of Arts degree is offered to students who qualify in the field of general economic theory and in one other field within the college. For the Master of Science degree, the requirements are as specified for the M.A. plus Economics 352, Advanced Statistical Methods (3), and Management 302, Quantitative Methods–Conceptual (3).

Eighteen of the minimum of thirty hours required for a master's degree must be taken within the College of Business and Economics. Up to twelve hours of the thirty-hour requirement may be elected from related fields in any department of the University with the consent of the chairman of the doctoral committee.

The Master of Science 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 areas as accounting, finance, marketing, production and public service. This integration will provide the student with a broader perspective toward managerial decision-making in private enterprise and/or public administration. Undergraduate students with prior exposure to engineering, business, economics, mathematics or the physical sciences who desire a professional career as a staff specialist in management science will be ideal candidates for the program. In addition, those students who are experienced in, or intend to fill, line manager positions would find the management science background advantageous in dealing with the increasingly complex problems of industrial, commercial, and public service organizations. For additional information see: Interdisciplinary Graduate Programs; Management Science.

College of Engineering and Physical Sciences

John J. Karakash, *Dean*
Robert Gallagher, *Associate Dean*
Arthur F. Gould, *Associate Dean*

The Curricula

The college offers curricula in chemical engineering, chemistry, civil engineering, electrical engineering, mechanical engineering and engineering mechanics, engineering physics, fundamental sciences, industrial engineering, and metallurgical engineering and materials science. Each leads to the degree of bachelor of science in the designated area.

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 has General Study requirements in the humanities and social sciences.

In the past engineering education was identified explicitly and uniquely in terms of the needs of industry. Present-day engineering programs continue to provide and emphasize such preparation. However, the flexibility inherent in the curricula enables students to design personalized programs leading directly into other professional colleges or professions such as medicine, law, government, management or architecture. The college encourages such mobility. Experience shows that the background provided through the college programs, including "the engineering approach" to identification and resolution of problems, finds increasingly wider applicability in those areas of activity which call for a combination of practical and conceptual intelligence.

The science curricula of the college stress fundamentals while providing opportunities for electives in each of the substantive fields within the sciences. Senior-year programs in the sciences can be planned to facilitate transition to either graduate school or industrial laboratories.

Undergraduates with interests in such topical areas as environmental control, biomedical instrumentation, computer or computing sciences, aerospace, or management can pursue their interests through electives provided in each of the curricula. Effective preparation for graduate study in such specialties consists of basic programs in science and engineering along with electives especially chosen for the field of interest. Such electives may be chosen from among all the offerings of the University and are usually taken during the last two years.

The early indication of curriculum choice by students in their application to the university is not a commitment on their part. In the second semester of the freshman year, just prior to preregistration for the sophomore year, students indicate their choice of curriculum. Since the sophomore-year programs for several curricula are very much alike, it is possible for a student 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 student 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.

The college recognizes that the four-year programs are not intended to train specialists in a given area but rather to educate students in terms of principles they will apply to problems they encounter in their future professional work. It is for this reason that the degree awarded upon graduation is bachelor of science in a particular division of engineering or science.

Five-year programs combining the liberal arts and engineering, business administration and engineering, or electrical engineering and physics are also provided. In each of these combined curricula one bachelor degree is awarded upon the successful completion of four years of study, and a second bachelor degree is awarded at the end of the fifth year. Completion of one additional year at the graduate level leads to the master of science degree in the preferred field. Similar programs lead to a master of science degree in Materials, or a Master in Business Administration.

Students initially planning four-year programs leading to bachelor of science degrees in any one of the college programs and who later decide also to earn a bachelor degree in any other major field of study, can proceed toward this objective provided they have reached this decision prior to their third year. In many instances this can be accomplished with one additional year of study.

The college curricula are designed to provide students with as much latitude as can be made available

without compromising the balance and integrity expected of them by accrediting agencies. This is satisfied with the "minimum" program of each curriculum. On the other hand, the college expects each of its students to take full advantage of all opportunities open to them and to complete "normal" programs. In each of the college curricula, a few junior- or senior-year electives are indicated as follows: Elective (0-3), or Electives (3-6), (6-9), etc. Normal programs are those including the higher of the two credit hours shown for each such elective, and minimum programs are those including the lower of the two numbers.

The college, through its advisors, is prepared to help students to use the six to twelve hours of "personal electives" which make the difference between the minimum and normal programs, along with other electives as available in the curricula, toward a personal-interest development program. This may take the form of some concentration in an option or specialty within a student's own degree program, or alternately in a topical area outside a student's own department or outside the college.

Qualified college juniors planning to continue their formal education into graduate school are urged to take advantage of this flexibility to design their senior-year program in a manner which comprises the beginning of a master's degree program at Lehigh. Qualified students who plan their programs in this manner can, upon recommendation of the department and with approval of the Dean of the Graduate School, receive credit toward their M.S. degree for those graduate-level courses they complete over and above their minimum undergraduate program.

Recommended freshman year

The following outline of work for the freshman year is most easily scheduled and satisfies the requirements for all students in the college. For schedules of the work required in the following three years, please refer to the specific curricula listed later in the catalog.

Freshman year, first semester (15-16 credit hours)

Engl 1	Composition and Literature (3)
Chem 21, 22	Introductory Chemistry Principles & Lab (5) or
Phys 11, 12	Introductory Physics I & Lab (5)
Math 21	Analytic Geometry & Calculus (4)
Engr 1	Introduction to Engineering Problems (3) or
GS	Social Science GS Elective (3 or 4)

Freshman year, second semester (15-16 credit hours)

Engl 2*	Composition and Literature (3)
Phys 11, 12	Introductory Physics I & Lab (5) or
Chem 21, 22	Introductory Chemistry Principles & Lab (5)
Math 22	Analytical Geometry and Calculus II (4)
Engr 1	Introduction to Engineering Problems (3) or
GS	Social Science GS Elective (3 or 4)

*English 10,14, or 16 may replace English 2.

Engineering 1, Introduction to Engineering Problems, is a three-hour course offering programming of elementary engineering problems in compiler language through lecture and preparation of problem solution in fields represented by the college curricula. Students elect a three-credit social science course (GS) from the fields of government, history, international relations, or social relations.

General Studies

The General Studies program is designed to enable students to range widely or to delve deeply into the humanities or the social sciences with the purpose of exploring the value systems, assumptions, and methodologies contained in these areas. Since all students in the college are expected to complete specified sequences of courses in the physical sciences, and other electives are available for related courses in natural sciences, the general studies program is restricted to the humanities and social sciences.

In addition, students pursuing a B.S. degree program in the college can, if they so choose, organize their general study program to achieve the equivalent of a "minor" in any one of the established areas in the humanities or social sciences. This requires:

1. Identifying the area of interest, i.e., sociology, philosophy, fine arts, literature, etc., and obtaining the approval of the chairman of general studies. A conference with the chairman of general studies is the first step toward this goal.

2. Formulating a course program in the area of concentration jointly with a member of the faculty representing the area of concentration. The names of faculty representatives will be given to students by the chairman of general studies.

In general, the "minor" is earned upon successful

completion of a program of not less than 15 credit hours in the area of concentration. In certain cases a senior paper also may be required. In each and every case the faculty advisor in the area of concentration must recommend the student's work for such recognition. It is essential that students planning to earn a minor in general studies initiate action soon after their freshman year but not later than the beginning of their fifth term.

The general studies sequence of the college starts in the freshman year with six hours of English composition and literature, and a three-hour social science elective. In the sophomore year four hours of economics are required. By the end of the senior year, a minimum of 12 additional hours (four courses) is completed to satisfy the requirement of a total of twenty-five hours in general studies. Several courses such as History 1 and 2, Course of Civilizations, and Philosophy 100, Philosophy of Contemporary Civilizations, have been developed to meet general studies objectives.

Courses qualifying for credit in general studies are as follows:

Required courses (10 credit hours)

English 1, and one course from among English 2, 10, 14 or 16.
Economics 1

Elective courses in humanities and social sciences (15 credit hours)

Classics: any course

Economics:

Eco 129	Money and Banking (3)
Eco 206	Microeconomic Analysis (3)
Eco 219	Microeconomic Analysis (3)
Eco 303	Economic Development (3)
Eco 305	The Economic Development of Latin America (3)
Eco 313	History of Economic Thought (3)
Eco 309	Comparative Economic Systems
Eco 310	Economic Evolution (3)
Eco 311	Economics of Resource Use (3)
Eco 312	Urban Economics (3)
Eco 335	Labor Economics (3)
Eco 337	Transportation and Spatial Economics (3)
Eco 338	Labor Market Institutions (3)
Eco 343	European Economic Integration (3)

English: any literature course

Fine Arts: any course

Foreign Language: any language course on the intermediate or elementary level, classical or modern. (If elementary language study is elected, a minimum of five hours must be in one language in order to receive general studies credit. A student may not elect an elementary course in any language in which he has entering credit.)

Government and Urban Studies: any course

History: any course

International Relations: any course

Journalism:

Journ 12	Reporting of Public Affairs (3)
Journ 21	Creative Writing (3)
Journ 22	Creative Writing (3)
Journ 111	Problems in Advanced Reportage (3)
Journ 115	Interpretive Writing (3)
Journ 118	History of American Journalism (3)
Journ 120	Journalism Proseminar (3)
Journ 121	Law of the Press (3)
Journ 122	Law of the Press I (3)
Journ 311	Science Writing (3)
Journ 312	Science Writing (3)

Music: any course except Music 1-4, 5-8, 9, 10.

Philosophy: any course

Psychology:

Psych 4	Psychology as a Social Science (3)
Psych 107	Child Psychology (3)
Psych 108	Adolescent and Adult Psychology (3)
Psych 121	Encountering Self and Others (3)
Psych 131	Psychology of Women (3)
Psych 205	Abnormal Psychology (3)
Psych 211	Insanity: Psychological and Legal Views (3)
Psych 301	Human Factors in Socio-Technological Systems (3)
Psych 320	Psycholinguistics (3)
Psych 331	Humanistic Psychology (3)
Psych 353	Personality Theory (3)
Psych 354	Personality Assessment (3)

Religion Studies: any course

Social Relations: any course

Speech:

Speech 30	Fundamentals of Speech (3)
Speech 61	Theatre Production (3)
Speech 62	Theatre Production (3)

Graduation requirements

Students in good academic standing earn their degree by meeting the requirements of their specific bachelor of science curriculum and University requirements. Waiver of program requirements is approved through petition endorsed by the department and the Committee on Standing of Students. 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 by the curriculum. Advanced military science or aerospace studies can be included within the normal program of each curriculum, but not within the minimum program. Students are urged to confer with their curriculum advisor on all matters related to their program.

Honors programs

Each department offers honors work, and adapts this to its curriculum.

Outstanding students may receive permission to do independent study on an unscheduled basis, thereby proceeding more rapidly and more deeply than is possible in regular programs. This enables students who are qualified for and interested in this work to proceed in a direction agreed upon with their honors advisor, leading to the preparation of an undergraduate thesis. For further information students should see their advisor.

Inspection trips

Inspection trips to industrial 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. The location of the University in the center of industrial activities of various types furnishes unusual opportunities for visits of inspection to engineering plants.

Arts-Engineering curricula

Under the five-year plan the student is in the College of Arts and Science for four years, earning the B.A. degree on completion of a program which includes, along with specific B.A. training, the fundamental mathematical, scientific, and engineering subjects of the chosen engineering curriculum. In the fifth year the student is enrolled in the College of Engineering and Physical Sciences, carrying on a program leading to the B.S. degree in the selected curriculum.

Engineering students who decide at any stage of their program to work for both the B.A. and B.S. degrees are urged to work with their advisors toward the formulation of an augmented program meeting the requirements of both degrees. If the decision is made prior to the third year, both degree requirements may be satisfied within a total of five years.

The General College Division

The General College Division supplements the work of the established undergraduate curricula by meeting the educational needs of certain special groups of students. The division aims to provide an opportunity for individuals, not planning a four-year program, to pursue such work, either of a general or a more specialized nature, as their preparation and interests make desirable; a trial period for those who wish to become candidates for baccalaureate degrees but whose preparatory training does not fully satisfy the entrance requirements for the curricula of their choice; and facilities for qualified adults to continue their education without being committed to a restricted or specialized program.

Although all work available through the General College Division will be found at present among the regular offerings of the several departments, the work taken by students enrolled in this division is not regarded as primarily preparation for admission to the upper classes of the University; rather, the courses are looked upon as complete in themselves.

Each student in the General College Division has an individual program, one not subject to distribution or curriculum requirements, yet one limited by the student's ability to meet the prerequisites of the courses which he or she desires to take. With but few exceptions, the student enrolled in this division enjoys the same privileges as all other undergraduates in the University, including eligibility to unrestricted prizes, access to student aid, and the right of petition; and is also subject to the same general regulations, those pertaining to scholastic probation not excepted. The General College Division student will not, however, be a candidate for a degree, save in those instances where transfer to one of the undergraduate programs of study leading to degrees is approved by the Committee on Standing of Students.

Research Organizations

Bureau of Educational Service

The Bureau of Educational Service was organized in 1953 to provide professional assistance to public and private schools and various other educational groups.

Among the purposes of the bureau are the rendering of professional assistance to educational institutions by a cooperative study of their problems, fostering research in the field of educational practice, and helping to make the resources of the University more readily available to communities and agencies in need. In fulfilling these purposes the bureau obtains the services of specialists from all areas of the academic profession.

Detailed information on assistance with specific problems can be secured from the Director, Division of Educational Administration, School of Education, Lehigh University, Bethlehem, Pa. 18015.

Office of Research

The Lehigh Institute of Research was organized in 1924 to encourage and promote scientific research and scholarly achievement in every division of learning represented in the organization of the University, and in recognition of the need for further and more exact knowledge in science and in the application of science to the affairs of modern life. The institute was reorganized in 1945 in recognition of the increasing role of government agencies and industry in sponsoring research, and renamed in 1968 in recognition of its administrative function.

Council for Research in Teaching and Learning

The University Council for Research in Teaching and Learning is an interdisciplinary effort to support the interests among groups of faculty members in research and development activities to enhance the teaching-learning process. Formed as task forces, these groups pursue common interests in such areas as computer applications, educational technology, programmed learning, delinquent education, and many others. A significant aspect of the council's work is that it encourages research and development activities relevant to the Lehigh community and to the educational community at large.

4

The Graduate School

Robert Daniel Stout, *Dean*

Areas of advanced study

Graduate study was a part of the original plan of the University and was announced in its first Register in 1866. More definite organization of the work along lines that are now generally accepted dates from 1883. Since that time the degrees of Master of Arts and Master of Science have been offered without interruption. The degree of Doctor of Philosophy was also announced for a time and twice conferred. In the middle 1890s this degree was withdrawn and doctoral work was not offered until 1936, when it was once more authorized by the trustees. In the same year the Graduate School was organized, with its own faculty. In 1960 a program of studies leading to the degree of Doctor of Education was offered. A Doctor of Arts program was begun in 1971.

The Graduate School, in certain areas, offers qualified students opportunity for intensive advanced study and for specialized training in methods of investigation and research, with a view to their development as scholars and independent investigators. The school also aims to serve the needs of teachers and prospective teachers in elementary and secondary schools by providing opportunities for advanced professional training, and by preparing them for administrative positions.

Major work leading to the master's degree may be taken in the following fields: applied mathematics, applied mechanics, biology, business and economics, chemical engineering, chemistry, civil engineering, computer science, economics, education, electrical engineering, English, geology, government, history, industrial engineering, information sciences, management science, mathematics, materials, mechanical engineering, metallurgy and materials science, modern foreign languages and literatures, molecular biology, physics, physiological chemistry, political science, psychology, and social relations. In the fields of Greek and Latin, advanced degrees are not offered; but students majoring in other fields may take collateral work in these fields from the list of courses acceptable for graduate credit.

Work leading to the doctor's degree is offered in the following fields: applied mathematics, applied mechanics, biology, business and industrial economics, chemical engineering, chemistry, civil engineering, economics, education, electrical engineering, English, geology, government, history, industrial engineering, information sciences, mathematics, mechanical engineering, metallurgy and materials science, molecular biology, physics, physiological chemistry and psychology.

Admission to graduate standing

A graduate of an accredited college, university, or technical institution is eligible for consideration for admission to the Graduate School at Lehigh University. Actual admission is subject to enrollment limitations in each department and is therefore competitive. An application for admission to the Graduate School may be secured from the Office of Admission. The candidate should file this application as far in advance as possible of the beginning of the semester when he or she wishes to undertake graduate work, but in any event, at least ten days before the start of classes. In addition to the application the candidate should also request that each institution of higher learning which he or she has attended send directly to the Office of Admission a transcript of the academic record. An application fee of $10 will be charged.

A prospective graduate student is invited to communicate directly with the chairman of the department in which he or she is interested. If it is conve-

nient for the person to visit the University prior to completing admission or prior to registration, a consultation with the chairman of the department (or a representative) will assist the department in working out a program and will aid the student by providing a better understanding of the facilities and opportunities for graduate study at the University.

The submission of Graduate Record Examination scores by a student applying for admission is urged. (For information about this examination, write to the Educational Testing Service, 20 Nassau St., Princeton, N.J. 08540). If a student is applying for admission to graduate work in education, scores may be submitted for either the Graduate Record Examination or the Miller Analogies Test. Candidates for graduate work in business administration may submit scores for the Admissions Test for Graduate Students in Business. In all three instances, test scores may under certain circumstances be required.

Foreign students are required to submit evidence of competence in use of English. Tests such as those administered by the International Institute of Education or the Educational Testing Service are suitable.

Admission to graduate standing permits the student to take any course for which he or she has the necessary qualifications. It does not imply admission to candidacy for a degree. Admission to candidacy for an advanced degree is granted in accordance with the provisions set forth below under Degrees.

A graduate student who is absent from the University for a semester or more must obtain the written approval of the chairman of his or her major department in order to be readmitted to graduate standing. If the student has not established a major, he or she must obtain the approval of the Dean of the Graduate School.

Students of Lehigh University who are within a few hours of meeting the requirements for the bachelor's degree may, if given permission by the Graduate Committee, enroll for a limited amount of work for graduate credit.

Resident graduate student

A resident graduate student is one whose primary activity is work toward an advanced degree. The individual must be registered for at least nine semester hours of research and/or course work toward the degree, and may not receive income from any employment requiring services totaling more than twenty hours per week.

Special student

A student who does not wish or may not qualify for admission to the Graduate School as a graduate student may apply to the Office of Admission for admission as a special student. The person must hold a baccalaureate degree or have equivalent experience. He or she may register only for courses up to and including the 300 level at the standard tuition rate. Admission depends on approval by both the relevant major department and the Graduate School office. Satisfactory performance as a special student may qualify the student to apply for admission to the Graduate School but no courses taken as a special student may be submitted for credit toward a graduate degree.

Registration

Several days are set aside for graduate registration just prior to the beginning of the semester as indicated in the calendar. However, a student, once admitted, can complete advance registration anytime in January, June or August, as the case may be, by obtaining a registration ticket from the department and arranging in advance for an interview with his or her advisor. Anyone who can register in advance is urged to do so. Normally students are expected to complete their registration before the close of the third day of instruction. Registration after the tenth day of instruction in a regular semester or the fifth day in a summer session is permitted only when the express consent of the Dean of the Graduate School has been obtained. A $10 late registration fee will be charged. Unregistered students are not permitted to attend classes beyond the ten-day grace period.

It should be noted that graduate work itself starts promptly at the beginning of the term, and it is frequently true that graduate courses can be given only if there is a certain minimum demand for them. Delay in enrolling for a given course may therefore cause the course to be withdrawn.

Tuition and fees

The tuition in the Graduate School is $1,650 per semester or $138 per semester hour for 1975-76. An increase in this amount is likely for 1976-77. A listen-

er's fee is charged for each course audited, unless the student is already paying the full tuition fee. The maximum full-time roster of graduate courses, including audited courses, is 15 semester hours. No exception to this rule is made. All students using the resources of the University must be registered, including the semester in which they receive a degree.

In addition to the usual tuition, an intern student is required to pay a $450 per year intern fee.

Bills are paid at the Bursar's Office. If desired, payment may be made in installments: 60 percent plus a service charge of $3 per semester, due prior to registration; 20 percent due one month after registration; 20 percent due two months after registration. The $3 service charge is not refundable.

The University will award educational grants to all qualified elementary and secondary school personnel enrolled in the Graduate School. These grants for teachers, either in full-time service or on leave from such appointment, amount to $768 per semester or $64 per semester hour in 1975-76.

To qualify for the doctorate, all students must pay tuition fees equivalent to three full years (90 credit hours) beyond the bachelor's degree or two full years (60 credit hours) beyond the master's degree. Until these fees are met, resident doctoral candidates must pay a minimum registration fee of $1,150 each semester and summer period. Similarly, part-time doctoral candidates must register for a minimum of three credit hours of courses or dissertation until the fees are met. Thereafter doctoral candidacy must be maintained by a registration fee of $150 per semester and summer period until work for the degree is completed. However, resident students who, during their entire doctoral program, have paid continuously full tuition (or ten hours per semester in the case of teaching assistants and research assistants) will be considered as having satisfied the tuition requirements for the doctoral degree upon completion of all other degree requirements.

Doctoral candidates registering for dissertation should indicate credit hours corresponding to the tuition paid (calculated at $138 per credit hour). This procedure will assure that proper credit toward the minimum tuition fees is recorded. When the sum of course credits and dissertation credits rostered beyond the master's degree (or its equivalent of 30 semester hours) reaches a total of 60 semester hours, the minimum tuition fees will have been met. The Dean of the Graduate School should be consulted in any case where the proper amount of the registration fee is in doubt.

The fee for each language examination required of the student by his or her department is $10.

The fee for microfilming and binding of the master's thesis is $15, the receipt for which is presented with the completed thesis to the Graduate School Office.

In the case of the doctorate, the publication fee is $35. If a copyright of the dissertation is desired, an additional fee of $15 is required.

Identification cards, entitling the holder to attend the various campus events, are issued to graduate students at a fee of $10 for the full academic year, and $5 for the period from January to June. Students registered for nine credit hours or more are entitled to an identification card without charge.

Transcripts

Each student is entitled to one copy of his or her record free of charge. This can be an official or unofficial transcript. Unofficial copies are released to the student; official copies are sent directly to the educational institution, company, state board, etc., as the circumstances may require. After the first copy is released, a fee of $1 is assessed for each subsequent copy.

Refunds

A graduate student who formally withdraws from the University or who, on the advice of the department chairman and with the approval of the dean, finds it necessary to reduce the roster below twelve hours in any regular semester, may qualify for a tuition refund. The amount of refund is equal to the tuition paid for the course or courses being dropped, less 15 percent of this tuition for each full or fractional week of the semester computed from the date of the beginning of instruction in courses open to graduate students. There is no refund for semester hours dropped if the remaining roster totals 12 or more hours.

A summer session student who formally withdraws from the University is entitled to receive a refund of his or her total tuition less $5 for each credit hour for which he or she is registered and less a deduction for each day of regular instruction of four percent of the total tuition paid computed from the first day of

instruction in the session.

In the event of the death of a student or involuntary induction into the armed forces, fees will be refunded in proportion to the fraction of the semester remaining at the time of death or induction.

A student who is suspended or expelled from the University is not entitled to any refunds.

Degree information

The maximum roster of a full-time graduate student is fifteen semester hours. Graduate students who are employed elsewhere and can give only part of their time to graduate work must restrict the size of their rosters accordingly.

Graduate students who hold University appointments of any kind are permitted to enroll for only a limited amount of graduate work. Full-time employees of the University may not take more than six semester hours of graduate work in any one semester; half-time employees may not take more than ten semester hours.

With the consent of the chairman of his or her major department and the chairman of the department concerned, a graduate student may be admitted as a regular listener in one or more courses, which course(s) shall be outside his or her approved program of studies for the degree, provided that the total number of hours in which he or she is registered and in which the person is a listener shall not exceed the limits set forth above. In no case shall a student who has attended a course as a listener be given an examination for credit in that course. A listener's fee is charged for each course audited.

Students desiring to qualify for graduate degrees in the minimum time should have pursued an undergraduate major in the subject equivalent to that offered at Lehigh. At the discretion of the chairman of the department, a limited number of credits in closely allied subjects may be accepted in lieu of courses in the undergraduate major. Those with undergraduate deficiencies who are admitted because they are otherwise well qualified will be expected to make up such deficiencies in addition to satisfying the minimum requirement for the degree sought.

Filing of application for degree

Candidates for degrees to be conferred on University Day in May or June file with the Registrar, on a form provided for the purpose, on or before April 1, a written notice of their candidacy; candidates for degrees to be conferred at Founder's Day in October file a similar notice on or before September 10; candidates for degrees conferred in December must file on or before December 1. Failure to file such notice by the dates mentioned may bar the candidate from receiving the degree at the ensuing graduation exercises. If a late application can be accepted, the candidate is assessed a $10 fee to help cover the extra cost of processing.

In addition to the degree requirements set forth below, there may be departmental requirements in the field of the major. These requirements appear in the separate departmental statements in the section, Description of Courses.

Master's degrees

The master's degree is granted to properly qualified students who complete satisfactorily at least two full semesters of advanced work. In meeting the requirements for the degree, the student must comply with the following regulations.

Each candidate for the master's degree must submit for the approval of the Graduate Committee the program of courses he or she proposes to take to satisfy the requirements. This program must have the approval of the chairman of the student's major department, and all courses included which are not offered by the student's major department must also be approved by the chairman of the departments concerned. The program should be submitted as soon as possible after completion of 15 credits toward the degree. Approval of the program by the Graduate Committee signifies that the student has formally been admitted to candidacy for the degree.

The minimum program for the master's degree includes:

a. Not less than thirty semester hours of graduate work;

b. Not less than eighteen hours of 400-level course work;

c. Not less than eighteen hours in the major field;

d. Not less than fifteen hours of 400 courses in the major field.

The eighteen hours required in the major field are ordinarily taken in one department. Specific exceptions to this rule are mentioned in the departmental statements at the head of course listings. The remain-

ing twelve hours of a minimum program, or any part of them, may also be taken in the major department; or they may be taken in any other field in which courses for graduate credit are offered, as the needs or interests of the student may indicate, subject to the approval of the chairman of the major department. In all cases, the work for the master's degree must be taken under at least two instructors.

Graduate students registered in 200- and 300-series courses may be assigned additional work at the discretion of the instructor.

In order to qualify for the master's degree, candidates will be 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 specify both. If required, the thesis shall not count for more than six semester hours. The credit to be allowed shall be fixed by the chairman of the major department. One unbound typewritten copy of the thesis, approved by the faculty members under whom the work was done and by the chairman of the major department, shall be placed in the hands of the Dean of the Graduate School with a receipt for $15 to cover the fee for microfilming at least three weeks before the day on which the degree is to be conferred. Information as to the form in which the thesis must be presented may be obtained from the Office of the Graduate School.

The master's degree is not granted unless the candidate has earned the grades A or B in at least eighteen hours of academic work. No course in which the grade earned is less than C is credited toward the degree. A student who receives more than four grades below B in courses numbered 200 or higher becomes ineligible to qualify for the master's degree or to register for any other 400 courses.

All work which is to be credited toward a master's degree must normally be done in attendance at Lehigh University, and must be completed within a six-year period.

When all requirements have been met, the candidate is recommended by the faculty to the trustees for the master's degree appropriate to the work pursued.

Doctor of Philosophy

The degree of Doctor of Philosophy is conferred on candidates who have demonstrated general proficiency and high attainment in a special field of knowledge and capacity to carry on independent investigation in that field as evidenced by the presentation of an acceptable dissertation embodying the results of original research. The requirements are more specifically set forth in the following regulations.

Candidacy

Time requirements. A candidate ordinarily is expected to devote three or more academic years to graduate study. In no case is the degree awarded to one who has spent less than two full academic years in graduate work. Study for any specified period of time, however, is not in itself regarded as sufficient ground for awarding of the degree.

Graduate work done in residence at other institutions will be accepted in partial fulfillment of the time requirements, provided such work is approved by the Graduate Committee and by the departments concerned.

Work of fragmentary character scattered over a long period of years, or work completed many years before the student becomes a candidate for the degree, is subject to special review by the Graduate Committee. The extent to which such work may be credited towards the fulfillment of the time requirements will be decided by the Committee. All post-baccalaureate work submitted in a program for the Ph.D. degree must be completed within a ten-year period. Candidates entering the doctoral program with a master's degree from another institution or after a lapse of several years must complete work within a five-year period.

Residence requirements. A candidate for the degree must complete at least one full academic year of resident graduate study at Lehigh University. The candidate is required to maintain continuous registration until he or she completes all requirements for the degree, including the semester in which the degree is granted.

Approval of the doctoral program. Candidates for the doctorate are accepted in a limited number of departments only, and a department may limit the number of candidates accepted in any year. In passing upon a student's program, the committee will take into con-

sideration the applicant's general education, as well as his or her special qualifications for work in the chosen field. Each applicant is notified by the Dean of the Graduate School, in writing, of the action of the committee upon the application.

The student and his or her faculty advisor are expected to initiate steps for approval of the student's program in the first semester following completion of 30 hours of graduate credit. The department will determine by examinations or other credentials whether the student is qualified. Application should be submitted to the Graduate Committee not later than one year after completion of the master's degree or its equivalent. Information on the procedure to be followed can be obtained at the Graduate School Office.

The application of a foreign student must be accompanied by a statement from the department in which he or she intends to specialize, certifying that the student has a satisfactory command of English.

A special committee is formed to guide the student in his or her doctoral program. The student should consult with his or her advisor on the naming of the committee and the preparation of the application as early as possible after passing qualifying examinations or has been accepted by the department to pursue the degree. The committee is charged with the responsibilities of assisting the student and the advisor in formulating a course of study and preparing a suitable proposal for the dissertation, of overseeing the progress of the student in research, and of assessing the final dissertation. Four members are normally appointed, at least one of them from outside the department. The membership of the committee is approved by the Graduate Committee.

Plan of work. Preparation for the degree is based on the study of a major subject to which one or two minors may be added. The program of work, to be formulated by the candidate, his or her special committee, and the chairman of the major department, should be planned to lead to a general mastery of the major field and to a significant grasp of any minor that may be added.

While there is no definite requirement as to the number of courses to be taken, two years devoted to formal courses is customary.

Language requirements. Language requirements for the Doctor of Philosophy degree are the option of, and in the jurisdiction of, the candidate's major department. They are not a University requirement for the degree. Each major department shall decide which languages, if any, shall form a part of each candidate's doctoral program.

Language examinations are the responsibility of a committee consisting of representatives of the language department concerned and of the candidate's major department. Fee for each examination is $10.

Permission to take the language examinations does not imply admission to candidacy for the degree.

Examinations and dissertation

General examination. The general examinations for the doctorate are designed to test both the student's capacity and proficiency in his or her field of study. The examinations are not necessarily confined to the content of courses that have been taken at Lehigh University or elsewhere. They are held not later than seven months prior to the time when the candidate plans to receive the degree. The student's special committee is in charge of the examination, which may be both written and oral.

Should a candidate fail in any part of the general examinations, he or she may be permitted by the Graduate Committee to undertake a second examination not earlier than five months after the first. If the results of the second trial are also unsatisfactory no further examination is set.

Dissertation. The candidate is required to present a dissertation prepared under the general direction of a professor at Lehigh University. The dissertation shall treat a topic related to the candidate's major subject, embody the results of original research, give evidence of high scholarship, and constitute a contribution of knowledge. It must be approved by the professor under whose direction it was written, by the candidate's special committee, and by the Graduate Committee. A copy bearing written approval of the professor in charge must be presented to the Dean of the Graduate School for transmission to the student's special committee not later than April 15, if the degree is to be conferred in May or June; not later than September 1, if the degree is to be conferred in October, not later than November 9 if the degree is to be conferred in December.

In order that the student receive proper credit for tuition payments toward the minimum required, registration for dissertation should indicate the semester hours covered by the payment.

The candidate shall deposit with the Dean of the Graduate School, at least two weeks before the degree is to be conferred: (1) the original or perfect black and white typescript of the accepted dissertation, unbound, in standard form, and suitable for microfilming; (2) the first carbon copy of the accepted dissertation; (3) three copies of an abstract of the dissertation, not exceeding 600 words, accompanied by a letter from the dissertation supervisor stating that the abstract is acceptable and suitable for publication; (4) a receipt from the Bursar for the payment of the publication fee of thirty-five dollars ($35). The publication fee is used by the University to defray the cost of publishing the dissertation on microfilm (through University Microfilms) and the abstract in *Dissertation Abstracts.* If the candidate wishes to copyright the dissertation, he or she may do so by paying the copyright fee of $15 to the Bursar at the time the publication fee is paid. Arrangements for the copyright in the author's name will then be made by the University through University Microfilms.

Final examination. After the rough draft of the dissertation has been returned from the Graduate School, the student should distribute copies to the members of the special committee. The student will arrange a suitable date for the defense of his or her dissertation, allowing time for the special committee to examine the draft. The date is sent to the Graduate School Office for information. The examination is open to the public, and the department may enlarge the membership of the official examining committee as it sees fit.

Conferring of degree in absentia

The degree of Doctor of Philosophy will not be conferred in absentia unless the candidate is excused by the Dean of the Graduate School.

Doctor of Arts

The degree of Doctor of Arts is offered in the fields of business and economics, chemistry, government, and psychology for students who wish to prepare for a career of college teaching in one of those fields. In every respect, admission standards will be equal to those for the Ph.D. programs, and the D.A. programs have been developed in accordance with guidelines issued by the Council of Graduate Schools.

The requirements for the D.A. degree parallel 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 those students wishing bidisciplinary preparation for two-year college teaching; (3) course work and training in interpersonal awareness; (4) a supervised internship in college teaching, and (5) a project appropriate to college teaching in the field instead of a dissertation.

Doctor of Education

The degree of Doctor of Education is intended for a limited number of carefully selected students engaged in the fields of administration, counseling, foundations, reading, measurement and research, and teaching. Successful professional experience is required for admission to candidacy for this degree.

In general, requirements for the Ed.D. degree parallel those already stated for the Ph.D. degree with the exception of the following: (a) language examinations are not required; (b) a statistics competency examination is required; and (c) a residence requirement may be satisfied by an academic year of full-time study or a semester of full-time study preceded or followed by a summer session in which 12 semester hours of credit are earned.

There is enough flexibility in this program to permit certain modifications appropriate to the specific objectives and background of the doctoral student. For more detailed information, consult the Dean of the School of Education, and see the pages which follow in this section on the School of Education.

Postdoctoral work

Students who have completed the requirements for the doctorate may enroll for postdoctoral individualized study under the guidance of selected members of the faculty. Such a program of study contemplates a broad educational and research development at advanced and mature levels, and provides opportunities to prepare for specific positions. A formal certification of such work as may be accomplished by the student will be made.

Resources for graduate study

Since the University began in 1961 to encourage the growth of its Graduate School, resources available for graduate study have greatly increased. Considering

the graduate program to be composed of formal course instruction and a research experience, the University has developed means to enable students fruitfully to pursue such work.

Research provides a principal method of training and education at an advanced level by concentrated study on a specific problem under close direction of senior faculty members. Such study in theory and experiment assures that classroom teaching is up-to-date; thus research, classroom, and laboratory instruction complement each other.

Lehigh has numerous special laboratories to facilitate such research in the sciences and engineering. These laboratories are located in Fritz Laboratory, which houses the civil engineering department and the world's second-largest universal hydraulic testing machine; Whitaker Laboratory, completed in 1965 for the chemical and metallurgical engineering departments; Sinclair Laboratory, completed in 1970, for surface chemistry and coatings research; Packard Laboratory, for electrical engineering, mechanical engineering, mechanics, and the Computing Center, the most-used laboratory on campus; Williams Hall, for biology, geological sciences, psychology, and the bioelectric research laboratory; the Physics Building; the new Seeley G. Mudd chemistry complex, scheduled for completion during 1975; Chandler and Ullmann Laboratories; and Coxe Laboratory, for metallurgy and the electronic microscopy laboratory.

The University's Linderman Library houses more than 500,000 volumes in the humanities and social sciences, including the rare book collection. The Mart Science and Engineering Library houses 100,000 volumes and serves the fields of engineering, mathematics and the natural and physical sciences. Resources of other libraries are available.

Under certain programs, Lehigh graduate students have access to facilities at various industries in the area. Also, some of the major libraries of the country are within an hour's drive.

The University's policy is to make these resources available to all faculty and students, including undergraduates, but graduate students dominate student usage of the more sophisticated laboratory facilities and library holdings.

One manifestation of the growth of graduate education at Lehigh has been the organization of interdisciplinary centers and interdepartmental projects and cooperation. Recent success with mission-oriented research using an interdisciplinary approach—that is, scientists and engineers working together on a basic problem—promises an interesting kind of graduate education. Lehigh's interdisciplinary centers offer an opportunity to implement this new approach by directing continuous attention to a given group of problems, stimulating interest in their solution, and, finally, mobilizing the talent across campus required for meaningful research. Besides organizing research, the centers create new courses relative to their research.

Although most graduate students find their interests served by programs available within a single department, some may elect to work in interdisciplinary areas, which reach into two or more departments. Generally, each graduate student's program can be designed to fulfill his or her own particular interests, subject to the requirement that the field thus defined has scope and depth appropriate for an advanced degree regardless of whether its boundaries fall within a single department. Faculty do not regard departmental organization as a limit to the bounds of their scholarly interests.

General information

Campus events

The cultural and athletic events of the University are open to graduate students who request identification cards, and recreational facilities are for the use of all.

Lehigh University provides a wide range of social and athletic activities, concerts and dramatic productions, and art and book exhibits for students and their guests, for faculty, neighbors, and alumni.

Housing

Many resident graduate students live in rooms or apartments near the campus, although from time to time a limited number of living accommodations are available in the undergraduate residence halls on the campus. The university owns and operates the Saucon Married and Graduate Students apartment complex which opened in 1973. This facility, located in the Saucon Valley, provides efficiency, one-bedroom, two-bedroom, and three-bedroom garden-style apartments in a rural setting.

Inquiries in regard to accommodations for graduate students, either married or single, can be directed to the Residence Halls Office, Rathbone Hall, Lehigh University, Bethlehem, Pa. 18015. The University

cannot assume responsibility for locating housing. Since accommodations are scarce, the student is advised to arrange for housing well in advance of beginning residence.

Parking regulations

Graduate students are expected to comply with campus parking regulations. They should register their automobiles at the motor vehicle office, located in the Student Health Services building. No fee is charged for this registration.

Accident and sickness reimbursement insurance

The University requires all resident graduate students to carry the accident and sickness insurance coverage which is available at nominal cost at the Bursar's office, unless the student can present evidence of an approved coverage of his or her own.

All students are required to carry insurance for both accident and illness either through the University or by other approved policies.

Evening classes

For the benefit of graduate students who by reason of employment in the fields of teaching or industry cannot attend classes during the day, a certain number of courses are generally offered in the late afternoon, evening, and on Saturday morning. It cannot be announced in advance which courses these will be, but a student who is interested may receive the necessary information by communicating, before the beginning of each semester, with the chairman of the department in the field in which he or she is interested. In recent years evening and Saturday classes were held in accounting, business law, chemical engineering, civil engineering, economics, English, finance, government, history, industrial engineering, marketing, mathematics, mechanical engineering, metallurgy, and psychology. It is anticipated that in the future courses will be offered as the demand warrants.

Summer Session

During the summer, the University offers a comprehensive program for undergraduates and graduate students of two sessions of five weeks each. Many workshops and special programs dealing with extremely pertinent topics such as special engineering courses in surveying, reading and study developmental laboratory programs, overseas programs, and a variety of other special credit and non-credit workshops and conferences are offered. The special-interest programs are designed around the interest of the student population which normally is in attendance at Lehigh.

Financial assistance to graduate students

Scholarships and assistantships

Financial support is available to graduate students from a number of sources and in various forms—scholarships, fellowships, traineeships, teaching and research appointments. The University recognizes the high cost of graduate study, and encourages qualified students to explore all available sources of aid.

Scholarships. A scholarship is a grant which covers or helps to defray tuition. Each is awarded on the basis of academic promise and financial need. No services are expected in return.

Fellowships and traineeships. A fellowship or traineeship is a grant to a graduate student which covers tuition and provides an additional stipend to help meet living expenses.

The University receives funds from individual donors and corporations which provide for the support of several graduate students on scholarships, fellowships and traineeships. In addition, government agencies and foundations offer fellowships and other grants which they award either directly to outstanding students for use at institutions of their choice or to institutions for award by them to the student.

Appointment to these fellowships is for a period of two semesters and may be renewed, provided the work of the holder is of such quality as to justify continuation of financial aid. Usually the research work can be used for thesis or dissertation.

Annual stipends for most fellowships are $2,400 or more, depending upon the qualifications of the applicant. Graduate fellows pay the regular tuition fees. However, the graduate school, in awarding a fellowship, may award at the same time a graduate tuition grant. This grant provides remission of all tuition fees during the period for which it is awarded.

Teaching and graduate assistantships. Many graduate students hold junior academic staff positions as teaching or graduate assistants. They assist the faculty in grading undergraduate quizzes, instructing in the

classroom and laboratory, and conducting recitations.

The departments view seriously the benefits of a teaching or graduate assistantship as a preparation for a career in university teaching.

A number of teaching assistantships are available in applied mechanics, biology, business administration, chemistry, English, education, geology, government, history, international relations, mathematics, physics, psychology, and in chemical, civil, electrical, industrial, mechanical, and metallurgical engineering.

Half-time assistants devote 15 to 20 hours per week to their duties and receive $2,900 ($3,000 after one year of satisfactory service or to holders of the master's degree) for the academic year plus remission of tuition fees. They may take up to ten hours of graduate work a semester with remission of tuition.

Appointments to assistantships are made upon recommendation of the department chairman. A student who wishes to be considered for such a position should write directly to the department chairman. Forms for admission to the Graduate School should still be filed with the Office of Admission.

Research assistantships. Lehigh University cooperates with industrial concerns, technical associations and government agencies in carrying on basic and applied research. A number of research assistantships are available to qualified graduate students who assist with these research programs.

Many students value the opportunity to participate with senior faculty members in an ongoing project. The experience enlivens their course work and often determines one's thesis topic. Usually, a research assistant's thesis work parallels his or her contribution to the project.

Applications for research assistantships should be accompanied by evidence of the candidate's qualifications for the appointment sought and sent to the Director of the Office of Research or to the chairman of the department concerned.

Research assistants receive stipends up to $550 per month, depending upon the qualifications and academic programs of the appointee and the time assigned to the project. Appointments are generally for one year and normally are continued upon satisfactory academic progress. Part- or full-time employment on research projects is frequently available during the summer and entering students who hold research appointments usually are encouraged to begin their employment in June or July before the commencement of formal graduate study in the fall.

Research assistants holding appointments for half-time or more pay a uniform tuition of $1,150 per semester (for 1975-76) until they have met the tuition requirements of the degree for which they are candidates.

Applications. A student may apply for any of the scholarships, fellowships or traineeships awarded or administered by Lehigh University, including those granted by national agencies for presentation by the University, by completing the application form available from the Office of Admission. Each applicant is automatically considered for all awards for which he or she is eligible. Application must be completed on or before February 1. Each form must be supplemented by an official transcript of the candidate's college work, a statement concerning his or her practical experience, and any other evidence of qualifications which the student may choose to submit.

Scores made by the applicant in the Graduate Record Examination; or, for those in education, the National Teachers Examination; and for M.B.A. candidates, the Admissions Test for Graduate Students in Business, are desired whenever possible.

Final actions on applications are taken on the recommendation of departments to the Graduate School. Notices of award are mailed in March. In accordance with a resolution of the Council of Graduate Schools in the United States, to which over 180 graduate schools have signified their assent, a student has until April 15 to decline an award.

The holder of a scholarship, fellowship or traineeship may not accept any employment for pay without written permission of the dean of the Graduate School.

Student Loan Funds

The University administers a loan fund program under which financial assistance, long-term and short-term, is available to graduate students. A student may borrow when he or she has no other support from the University, or to add to income from a fellowship or assistantship. To be considered, a student must provide complete details of his or her budget.

Information concerning application for a loan may be obtained from the Office of Financial Aid. Available loan funds include:

National Direct Student Loan Program (NDSLP). As federal funds are available to the University, the

NDSLP makes it possible to borrow up to $2,500 each year for graduate study to a combined graduate/undergraduate total of $10,000 per person. The Office of Financial Aid is responsible for determining which students are eligible and the amount of the loan. Repayment begins nine months after the student ceases at least half-time study, and may extend over a ten-year period. Interest charges of three percent also begin at the start of the repayment period.

University Tuition Loan Program (UTLP). Loans are made available on the basis of need to graduate students carrying at least a half-time academic load. Interest charges of four percent annually begin from the date of the note. Repayment begins ninety days after the student ceases at least half-time study, at a minimum rate of $50 monthly.

The School of Education

John A. Stoops, *Dean*

History and purpose

The School of Education was established in 1966, elevating it from its former departmental status under the College of Arts and Science. The School of Education operates in conjunction with the Graduate School. Its administrative procedures are identical or similar to those of the Graduate School in regard to admission, registration, tuition, fees, transcripts, and other related matters. Degree requirements are also consistent with those established by the Graduate School. The School of Education offers the Master of Arts in Education, the Master of Education, the Master of Science in Education, and the Doctor of Education. Details regarding the specific regulations and requirements can be found in that section of this catalog pertaining to the Graduate School. Course offerings and other pertinent data may be found in the section, "Description of Courses."

The school is interested in the preparation of elementary teachers, secondary teachers, community college teachers, counselors, school psychologists, administrators, reading specialists, curriculum specialists, specialists in the foundations of education, specialists in the education of mentally and emotionally disturbed children, teachers of preschool children, especially those children with handicaps, teachers of nurses, teachers of vocational education and teachers for social restoration of potential delinquents. The Intern Teaching Program is specifically designed for qualified persons holding B.A. degrees who wish to enter the field of teaching. The school is particularly interested in established teachers who wish to prepare for leadership responsibility in the schools through preparation at the master's and doctorate levels. More than 1,000 students were involved in advanced study at the master's and doctoral levels in the 1974-75 academic year.

Through its working relationships with other colleges and universities in eastern Pennsylvania, Lehigh has undertaken to complement existing undergrad-

uate preparation programs by emphasizing study at the graduate level. Off-campus coursework and in-service projects are coordinated through the Office of Consortium Activities.

In addition, a fifth-year program is offered to a limited number of qualified holders of B.A. degrees who wish to enter teaching. Those admitted to the program have the opportunity to accomplish their professional training and serve as salaried interns in the public schools. At the completion of two semesters of directed full-time study, students may begin the teaching internship. After the completion of the fifth-year program and the required semesters of intern teaching, such students would ordinarily have completed requirements for the Master of Arts (secondary teachers) or the Master of Education (elementary teachers) degree.

For the benefit of in-service teachers, many courses are offered in the evenings and on Saturday mornings. Teachers of the Lehigh Valley and surrounding regions are encouraged to participate in the life and work of the University.

Programs of study

The School of Education offers the Master of Arts degree, major in Education with an academic specialty. Candidates for this degree must include in their program a minimum of twelve hours of graduate work in an academic field. The balance of the program is in the foundations of education and instructional process. The academic fields which now cooperate with the School of Education in offering this degree include: classical languages, mathematics, English, modern foreign languages, economics, government, social relations, history, international relations, and physical and natural sciences.

Lehigh's program of training for advanced professional responsibility is planned in three stages. The first is represented in the M.Ed., M.A., or M.S.; the second exists in the several specialist programs; and the final stage is the Ed.D.

The Master of Education degree requires, in addition to broad study of the social foundations of education, specialization in a professional field. Special fields include elementary education, elementary administration, secondary administration, general administration, elementary school counselors, secondary school counselors, community counselors, school psychologists, supervisors of guidance, school psychologists, special education, career education, and reading. Programs within the Secondary Division give opportunity for emphasis in reading instruction, the teaching of nurses, or social restoration. Although study at the master's level is intense and specialized, the school recognizes that additional training is needed for professional leadership in most areas. Therefore, programs designed for these specialties are extended to the post-master's level.

The Master of Science degree in educational measurements and research, open to both full- and part-time students, is designed to prepare its graduates for an increasing number of challenging positions involving research, testing, and evaluation in school districts, state departments of education, or other educational institutions.

The Doctor of Education program provides for major work in five areas: (1) administration, (2) reading, (3) educational foundations, (4) counseling, and (5) educational measurements and research. Students are screened for admission in the fall and spring of each year and begin doctoral study the following semester. Formal admission to the Ed.D. program usually occurs after the completion of 15-30 hours beyond the master's level. When the student has his or her proposal accepted by the Graduate School, he or she becomes eligible to take the general examination.

Education divisions

Division of Educational Administration
Charles W. Guditus, *director*
Elementary school principalship, secondary school principalship, school business managership, curriculum administration, school superintendency, community college teachers.

Division of Counselor Education
John A. Mierzwa, *director*
School psychologist, community counselor, elementary school counselor, secondary school counselor, supervisor of guidance.

Division of Elementary Education
Elvin C. Warfel, *director*
Elementary teachers (interns), elementary master teachers, reading, special education.

Division of Secondary Education
Robert L. Leight, *director*
Secondary school teachers (interns), secondary master teachers, educational foundations, career education, social restoration, teaching of nurses.

Interdisciplinary Graduate Programs

Computer Science

An interdisciplinary program is offered in computer science leading to the degree of master of science. It is supported by departments of the University with considerable resources in the field and an extensive list of course offerings. These departments and divisions also are active in research related to computer science, including the following:

1. In electrical engineering, research is under way in equipment organization, software engineering, coding theory, and devices for digital systems.
2. In information sciences, research is conducted in linguistics, information retrieval, and software systems.
3. In industrial engineering, research is concerned with operations research and management systems.
4. In mathematics research includes automata theory and mechanical theory-proving.

The computer science program is available to students from many undergraduate disciplines. In some cases background courses may be required to provide necessary prerequisites. The student should have the following preparation:

1. Skill in programming in a high-level language, and familiarity with a machine or assembly language.
2. Two years of college-level mathematics.

While the intention is to keep the program as flexible as possible to meet individual interests and needs, the student is normally expected to include in his or her program the following core subjects: mathematical methods in computer science; non-numerical programming; switching theory, and data structures.

Elective courses may be chosen from one or more of these areas: software and automata theory; hardware and logic design; numerical analysis; linguistics; computability; and applications.

A master's thesis or a research course must be included in the program to qualify for the degree. The student must be enrolled for administrative purposes in one of the following departments: electrical engineering, industrial engineering, information sciences, or mathematics. The program, however, is supervised by an interdisciplinary faculty committee headed by the dean of the graduate school.

Management Science

The industrial engineering department in conjunction with the department of management 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 areas as accounting, finance, marketing, and production. This integration will provide the student with a broader perspective toward managerial decision-making in private enterprise and/or public administration. Undergraduate students with a background in engineering, business, economics, mathematics or the physical sciences who desire a professional career as a staff specialist in management science are ideal candidates for the program. In addition, those candidates who intend to seek line manager positions would find the management science background advantageous in dealing with the increasingly 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.

Required courses include:

Simulation (I.E. 418)

Organizational Behavior and Structure (Mgt. 321, I.E. 334, or Mgt. 412)

Management Science Project (Mgt. [I.E.] 430)

Nine hours of Quantitative Methods

Six hours selected from a functional area.

The minimum program consists of thirty (30) hours of approved course work.

Sample M.S. in Management Science program

IE 418	Simulation
Mgt 321	Organization Behavior
IE 430	Management Science Project
IE 311	Decision Processes
IE 417	Mathematical Programming
Eco 455	Econometric Models
IE 325	Production Inventory Control
IE 425	Production Systems
Fin 421	Financial Management
Fin 431	Advanced Investment Analysis and Portfolio Management

Molecular Biology

Faculty from the departments of biology, chemistry, and physics have combined to offer an interdisciplinary program in molecular biology leading to the degrees of master of science and doctor of philosophy.

The core courses provide a basic background in cellular and molecular biology, biochemistry and biophysics. Present active research areas include studies of molecular analysis of microbial behavior, biomolecular radiation damage, mitochondrial nucleic acids, viral diseases of fish, proteolytic enzymes of marine bacteria, assembly of viruses, cardiac enzymology, and mechanisms of phosphate ester hydrolysis.

Students will be admitted to the departments of physics, chemistry or biology who have appropriate undergraduate preparation in the respective subject, or have backgrounds in molecular biology, biochemistry, biophysics, or microbiology. Their degree programs will be administered by the Molecular Biology Program Committee.

Master's degree requirements

The requirements for the M.S. degree in molecular biology consist of the following:

Attaining 30 credits of graduate course work, 18 of which are at the 400 level. Required courses are listed below.

Successful completion of a research project under the supervision of a committee member. A written report of the research must be approved by the research advisor and will be kept on file by the program committee.

Required courses for the M.S. degree in molecular biology

Chem 371	Elements of Biochemistry I (3)
Chem 372	Elements of Biochemistry II (3)
Phys 367	Introduction to Molecular Biophysics (3)
Phys 368	Molecular Biophysics (3)
Biol 420	Cellular Mechanisms (3)
Biol 447 (Chem 447)	Experimental Molecular Biology (3)
Chem 479	Biochemical Techniques (3)
Phys 491, 492; Biol 407, 408; Chem 474, 475	Research (6)
	Approved Elective (400 level) (3)

Total: 30 credits; 18 at 400 level

Electives

Students are encouraged to select additional courses from the following list. Other courses may be approved. Note that at least three elective credits at the 400 level are needed to satisfy the M.S. requirements.

Biol 325	Advanced Genetics (3)
Biol 353	Virology (3)
Biol 445	Nucleic Acids (3)
Biol 416	Immunology (3)
Biol 425	Biological Electron Microscopy (3)
Chem 358	Advanced Organic Chemistry (3)
Chem 458	Topics in Organic Chemistry (Bioorganic Mechanisms) (3)
Chem 476	Microbial Biochemistry (3)
Chem 477	Enzyme Kinetics
Phys 369	Introduction to Quantum Mechanics (3)
Chem 445	Elements of Physical Chemistry (4)

Doctoral degree requirements

Course requirements for the Ph.D. degree will be determined on an individual basis by the student and his or her dissertation committee. This determination is subject to approval by the program committee.

Before completing the requirements for the M.S. degree, a student who wishes to pursue a Ph.D. degree will take a qualifying examination, which may be both oral and written, and will be administered by the program committee. Upon successful completion of this exam (which may be taken no more than twice), the student, in consultation with the research advisor, will select a dissertation committee which will consist of the research advisor, at least three members of the Molecular Biology Program Commit-

tee, and at least one faculty member who is not a member of the committee. The dissertation committee must be approved by the program committee and by the Graduate Committee of the University.

Sometime prior to seven months before finishing the Ph.D. dissertation, a student must pass a general examination administered by the dissertation committee. The material covered in this examination will not be limited to material covered in courses or obtained through laboratory experience. The student may be tested on all and any areas of molecular biology.

Upon completion of a draft of the Ph.D. dissertation, the student will take the final exam, which will be essentially a defense of the thesis.

Physiological Chemistry

The graduate program in physiological chemistry is an interdisciplinary one leading to the M.S. and Ph.D. degrees. The purpose of this curriculum is to prepare individuals who wish to pursue careers in biomedical research, teaching, or administration, or in some aspect of public health.

Individuals enrolled in this program may elect to specialize in one of the following areas: nuclear medicine, medicinal chemistry, chemical and experimental parasitology and pathobiology, immunology, and chemical physiology. Students participating in this program are enrolled in the department of chemistry and are provided laboratory space in the various laboratories of the University's Center for Health Sciences.

The core courses required of each student are:

Chem 303	Nuclear and Radiochemistry (3)
Chem 336	Clinical Chemistry (3)
Chem 371	Elements of Biochemistry (3)
Chem 377	Biochemistry Laboratory (3)
Biol 333	Symbiosis (3)
Biol 416	Immunology (3) or
Biol 432	The Biology of Transplantation (3)
Phys 367	Introduction to Molecular Biophysics (3)
Educ 351	Statistical Methods in Research (3)

Students with the consent of their graduate committee members may petition to substitute equivalent courses for some of the required ones. In addition, each student selects, with the guidance of his or her committee, sufficient courses from the following to satisfy the requirements of the Graduate School.

Chem 310	Instrumentation Principles I (3)
Chem 311	Instrumentation Principles II (3)
Chem 372	Advanced Biochemistry (3)
Chem 378	Biochemical Preparations (2)
Chem 421	Chemistry Research (1-4)
Chem 441	Chemical Kinetics (3)
Chem 445	Elements of Physical Chemistry (4)
Chem 458	Topics in Organic Chemistry (medicinal chemistry, nuclear medicine, bioorganic mechanisms) (3)
Chem 471	Natural Products (3)
Chem 473	Seminar in Biochemistry (1-4)
Chem 476	Microbial Biochemistry (3)
Chem 477	Topics in Biochemistry (Chemical Basis of Parasitism, Immunochemistry) (3)
Biol 303	Invertebrate Zoology (3)
Biol 320	Cell Physiology (3)
Biol 322	Animal Physiology (3)
Biol 353	Virology (3)
Biol 402	Comparative Animal Physiology (3)
Biol 405	Special Topics in Biology (microbiology) (3)
Biol 413	Cytochemistry (3)
Biol 421	Morphogenesis of the Lower Invertebrates (3)
Biol 425	Biological Electron Microscopy (3)
Hist 339	Human Ecology and Public Health in America (3)
Hist 340	History of American Medicine (3)
I.R. 472	Special Topics (international public health policies) (3)

Students admitted into this program may have majored in biology, chemistry, animal science, entomology, veterinary science, pharmacy, or some other area of the life sciences.

All students in the Ph.D. program are required to satisfy one foreign language requirement and pass a qualifying examination. The completion of a research project is required of M.S. students. A dissertation is required of Ph.D. students.

Applied Mathematics

The Committee on Applied Mathematics administers programs leading to the degrees of master of science and doctor of philosophy. The programs leading to these degrees are interdepartmental and stress the application of mathematics to the physical and social sciences. They provide a broad, rather than a specialized, training in these fields.

The programs are also designed for candidates who

have a basic training, either at the B.A. or M.S. level, in a field other than applied mathematics. The committee encourages such applicants. The degrees will be in applied mathematics with a minor in some specified field of the physical and social sciences.

A candidate for these programs must have a knowledge of basic undergraduate mathematics which includes linear algebra and differential equations (for example, Math. 205). If not taken previously, courses in complex variable theory and partial differential equations, although not prerequisites for admission to these programs, must be added to the student's course requirements.

All students in the Ph.D. program are required to pass a qualifying examination before the end of their fifth semester (not including summer sessions). For the master of science degree, a thesis is required in addition to the course requirements. M.S. candidates can enter the Ph.D. program after completing all course requirements (exclusive of thesis). The date of the qualifying examination for a student entering the program with an M.S. degree—not necessarily in applied mathematics—will be determined on admission.

Several types of programs which are available to the student are listed below. These programs are not the only possible ones. Others can be arranged with the consent of the committee.

Core Courses

Math 320, 322
Che 464
(Physics 428 and 429 may be substituted for Math 320, 322)

Options

1. Engineering Sciences

Required:
Mech 411, 450
Electives:
Math 405
Mech 409, 421, 424,
Mech Eng 448, 458, 459
CE 459
EE 350, 409,
Phys 369, 442
Geol 301
Biol 402

2. Econometrics

Required:
Eco 206 or 432, 219 or 436, 351
Electives:
Math 309, 334
Eco 411, 453, 455, 456
IE 416, 418, 425, 426, 427, 429, 311

3. Applied Analysis

Required:
Math 309, 350
Mech 450, 411
Electives:
To be chosen from lists under Options 1 and 2.

Other Interdisciplinary Activities

Polymer research

The departments of chemistry, chemical engineering, and metallurgy and materials science, and two interdisciplinary centers, the Materials Research Center and the Center for Surface and Coatings Research, participate in the polymers program. While degrees are granted by academic departments, students may elect to carry out their thesis research in either academic departments or research centers. Students may elect any research problem and thesis advisor in the centers independent of departmental affiliation.

A broad range of polymer research programs and courses leading to the M.S. and Ph.D. degrees are available. Well-qualified students with degrees in chemistry, chemical engineering, metallurgy and materials science, or related fields are eligible. Lehigh has a strong professional staff leading graduate research programs, and offers a course sequence in polymers and closely allied areas.

For further information write: Prof. John A. Manson, Materials Research Center, Coxe Laboratory, Lehigh University, Bethlehem, Pa. 18015.

Solid state

Several solid-state research programs leading to the M.S. and Ph.D. degrees are available which cut across departmental lines. The departments of chemistry, electrical engineering, metallurgy and materials science, and physics, and two interdisciplinary centers, the Materials Research Center and the Center for Surface and Coatings Research, participate in solid-state activities. While degrees are granted by academic departments, arrangements may be made for students to carry out their thesis research in either research centers or academic departments, including departments other than their own.

A $5.25 million grant from the Fairchild Foundation to Lehigh for solid state education and research, announced in 1973, provides the following: the Sherman Fairchild Laboratory, a 16,000-square-foot structure scheduled for completion in 1976; two endowed professorships; eight graduate fellowships; ten undergraduate scholarships; and funds for new scientific equipment.

For further information, write to Prof. Frank J. Feigh, Materials Research Center, Coxe Laboratory, Lehigh University, Bethlehem, Pa. 18015.

Energy research

Energy research efforts are coordinated by the university's Task Force on Energy Research, which provides internal focus and communication for energy-related activities at Lehigh. Founded in 1972 to help develop faculty awareness of energy problems, it now serves as the major source of information on engineering trends and research opportunities.

Most of the departments in the College of Engineering and Physical 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 M.S.- and Ph.D.-level degree programs suitable for energy-related studies. All degrees are granted by academic departments. Graduate students may find their interests served by programs available within a single department or may elect to carry out their thesis research within two or more departments or within a research center. Each graduate student's program can be designed to fulfill the individual's own particular interests, subject to the requirement that the field thus defined has the scope and depth appropriate for an advanced degree.

For further information write to Professor Edward K. Levy, coordinator, Task Force on Energy Research, Packard Laboratory, Lehigh University, Bethlehem, Pa. 18015.

Research Centers and Organizations

Currently, nine interdisciplinary research centers and six institutes have been established at Lehigh University to assist the academic departments in developing the full research and advanced education potential of the University in special areas. The centers and institutes represent research thrusts based on the capabilities and interests of the faculty at Lehigh. Frequently, they relate to the broad-based research needs of government, industry and the social community.

The goal is to provide an effective interdisciplinary framework for programs involving faculty members and graduate students interested in combining traditional course programs with an interdisciplinary research experience.

The research centers, institutes and research-related organizations are administratively responsible to the Office of the Vice President—Research. The individual who holds this position, Dr. Joseph F. Libsch, has offices in Whitaker Laboratory.

Research centers

Center for the Application of Mathematics

Background and purpose

The Center for the Application of Mathematics was established in the fall of 1965. The purpose of the center is to foster interdisciplinary research related to the application of mathematics, to draw on other disciplines for pertinent mathematical problems, and to encourage the development of advanced courses in the application of mathematics.

The center surveys the need for courses in the application of mathematics and is concerned both with the design of new courses and the reorganization of existing courses so that these needs may be better served.

Research activities

Research programs are currently in progress in the center in the areas of non-linear continuum mechanics, the propagation of waves in non-linear media, variational calculus, numerical analysis and probability and statistics.

The program on non-linear continuum mechanics includes fundamental studies in the formulation of continuum theories, the study of anomalous flow phenomena in viscoelastic fluids, the study of finite elastic deformations and stability, and the thermomechanics of materials in which irreversible processes take place and long-range forces may be present.

The program on non-linear wave propagation includes fundamental mathematical studies of the propagation of both stress and electromagnetic waves in non-linear media and the application of these studies in a number of areas of physics. Among the areas currently being studied are the propagation of explosive waves in laminated media, the formation of severe storms, the formation of tidal waves and their modification by ocean and shore topography, and the generation of harmonics in high-intensity light beams, such as those produced by lasers.

Both the work on variational calculus and that on numerical analysis are mainly directed to the solution of non-linear elliptic differential equations. The work on probability and statistics is mainly in the area of time series analyses.

Educational opportunities

Through the Committee on Applied Mathematics, personnel of the center administer an interdisciplinary program leading to the degrees of master of science and doctor of philosophy. These programs are interdepartmental and stress the application of mathematics to the physical and social sciences.

For further information, write to the center's director, Professor Ronald S. Rivlin, 203 E. Packer Ave., Bethlehem, Pa. 18015.

Computing Center

Background and purpose

With a long heritage of teaching and research in the engineering and science disciplines, Lehigh has made extensive use of computers for more than a decade. In 1966, the need was recognized for an independent organization serving the diverse needs of the academic community and the Computing Center was formed. Today the center is charged with the responsibility of serving existing requirements while anticipating and preparing for the future requirements of its user community.

Located in Packard Laboratory, the Computing Center serves as a laboratory for departmental courses and research in computer theory and applications, including developmental programs. The center also provides computer services to all departments and centers of the University for solution of instructional, research, and administrative problems.

In the summer of 1968, the center installed a Control Data Corporation 6400 computing system. This system consists of 65,536 (60 bits each) words of central memory, ten peripheral and control processors, each with 4,096 words (12 bits each) of memory, approximately 800 million characters of disk storage, four magnetic tape units, two 1,200 line-per-minute printers, a 1,200 card-per-minute card reader, two incremental plotters, and a communications computer capable of supporting a wide variety of remote entry and display terminals and teletypes. The principal programming languages used with the large library of programs are FORTRAN IV, FORTRAN EXTENDED, COBOL, BASIC, and COMPASS (assembler). User areas are provided containing teletypes, key-punch machines, reference materials, and remote entry card readers and printers.

Research activities

To preserve its role of impartial support for all users, the center does not engage in primary research. It has, from time to time, conducted research-related activities on its own or in cooperation with academic departments or research centers. Its Computing Associates Program, wherein the center provides the mechanism for industry and government to work with University faculty in the identification and solution of computer-related problems, is a good example of

such an ongoing cooperative activity.

The center was funded by the National Science Foundation as the lead institution of a regional, educational computing network. Currently, six colleges and five high schools utilize the Lehigh computer through its telecommunications facilities.

The center's primary role in research is to support the computing activities of the research community. Approximately one-third of the computer utilization is devoted to this activity.

Educational opportunities

Seminars are held or sponsored by the center for faculty, staff and graduate students on varied subjects relating to data processing.

The center works closely with the Computer Society to meet the more independent inquiry needs of undergraduates and its advisor is a member of the center staff.

Graduate students desiring a more intensive educational experience in an operating environment may apply for one of the four teaching assistantships provided by the center.

As with research, the center's primary method of offering educational opportunities in the use of computers is by providing computing resources for use by the academic community. The majority of jobs processed by the center are submitted by students as a part of their normal academic activities. The growth of interactive processing facilities will benefit this group of users.

The University has established a multi-disciplinary graduate program leading to the M.S. in Computer Science degree.

For further information, write to the director, Professor John E. Walker, Computing Center, Packard Laboratory, Lehigh University, Bethlehem, Pa. 18015.

Center for Health Sciences

Background and purpose

The Center for Health Sciences was organized in 1972. It is concerned with interdisciplinary research and graduate and postdoctoral training in various aspects of the biomedical sciences and bioengineering. The center is comprised of four divisions: (1) the Institute for Pathobiology, (2) the Division of Biological Chemistry and Biophysics, (3) the Division of Bioengineering, and (4) the Division of Health Policy, History, and Information Services. Facilities are provided by these divisions for its members, postdoctoral fellows, and graduate students actively engaged in research in the respective areas. 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 health.

Research activities

The research opportunities and programs of each division are described below:

The Institute for Pathobiology. This institute, a branch of the Center for Health Sciences, is an interdisciplinary unit involved with research and graduate and postdoctoral education. Fields currently represented in ongoing research projects include virology, microbiology, protozoan and metazoan parasitology, invertebrate pathobiology, immunology, biological control, biochemistry, toxicology, epidemiology and epizootiology. A number of the current research projects are being funded by both public and private agencies, including biological control and parasitological studies overseas.

The administrative offices and principal laboratories of the institute are housed in newly renovated quarters in Chandler Laboratory. These facilities are well equipped for cytological, cytochemical, fine structural, immunological, physiological, biochemical, and tissue culture studies.

The following are some examples of research projects presently being carried out in the institute: possible biological control of invertebrate vectors of human and animal diseases by use of protozoan, bacterial, and viral pathogens; development of efficient molluscicides for the control of vectors of schistosomiasis and fascioliasis; studies on the intermediary metabolism and other phases of the biochemistry of helminth parasites; immunity to bacterial and parasite diseases; diseases and defense mechanisms of marine organisms.

Division of Biological Chemistry and Biophysics. This research and graduate training unit is a part of the Center for Health Sciences. Fields currently represented in ongoing research include enzyme biochemistry, intermediary metabolism, medicinal chemistry, biosynthesis of organic molecules, the physical basis of surface adhesion in biological systems, clinical

chemistry, effects of radiation on nucleic acids, nuclear medicine, and radiopharmaceuticals. Much of the research is being funded from private and federal agencies.

The administrative offices of the division and most of the laboratories are housed in Chandler Laboratory. The laboratories are well equipped and the major pieces of equipment include infrared, ultraviolet, and visible spectrophotometers, nuclear magnetic resonance instrumentation, mass spectrometers, fermenters, gas and liquid chromatographic facilities, and other allied bioorganic apparatuses.

This division has an ongoing liaison program with Hahnemann Medical College and Hospital and the clinical aspects of several research projects are being conducted at that institution.

Division of Bioengineering. This research and graduate training unit of the Center for Health Sciences is concerned with a number of health-related problems that are best resolved by individuals with a background in engineering. Specifically, ongoing projects include measuring the rigidity and tension of healthy and diseased blood cells, the mechanics of flow through the mammalian respiratory system, the fracture mechanics of skeletal units, and the development of prosthetic apparatus, and implant materials.

The division's laboratories are housed primarily in Packard Laboratory and the administrative office is in the same building.

Division of Health Policy, History, and Information Services. This research and graduate training unit of the Center for Health Sciences is involved in research and other activities in the health sciences which go beyond conventional laboratory and field research and development. Specifically, the staff and graduate students affiliated with this division are involved in a variety of studies including the economics of health services, the history of medicine and public health, international affairs as these pertain to world health, and the application of the computer in biomedicine. Some of the ongoing projects within this division include: an analysis of the economic and sociological impact of schistosomiasis, economics of health services, information retrieval of data on the effects of drugs on humans, and the history of yellow fever in the United States.

Educational opportunities

Graduate students working under the direction of members of the various components of the center may satisfy their course requirements towards the M.S. and Ph.D. degrees by selecting from the offerings of the departments of chemistry, physics, biology, civil engineering, mechanical engineering and mechanics, as well as other departments of the University. In addition, the interdisciplinary graduate program in physiological chemistry leading to the M.S. and Ph.D. degrees (see Interdisciplinary Graduate Programs) is supported by the Center for Health Sciences although all of the students are enrolled in the department of chemistry.

In addition to research, the center sponsors symposia as well as an annual series of seminars on topics pertinent to its objectives.

For further information write to the director, Professor Thomas C. Cheng, Chandler Laboratory, Lehigh University, Bethlehem, Pa. 18015.

Center for Information Science

Background and purpose

The Center for Information Science was established in 1962 as a division of the University library. It was reorganized in 1967 as an independent center for research and development with the objective of providing guidance and leadership in transdisciplinary studies of information systems and their operations.

In the last twenty years, the products of science and technology have not only posed unforeseen demands on libraries, but have also generated an entirely new complex of ideas concerning the processes of communication. Information science has emerged as a response to these needs and as the result of advances in computer technology. The field is concerned with the origin, dissemination, collection, organization, storage, retrieval, interpretation, and use of information.

Research activities

The center supports ongoing research projects in the theory, design, development, implementation, management, and operation of computer-based information systems. Facilities for this research, development, and operation include access to the CDC 6400 computer in both time-sharing and batch modes, remote card readers, printers, CRT terminals in the center and teletypes.

Specific research interests of the center include psycholinguistics, mathematical linguistics, and information retrieval. Research in psycholinguistics involves experimental studies of lexical memory, while activities in mathematical and computational linguistics concern the development of algorithms for the automatic analysis of English sentences. Information retrieval research deals with new techniques of full-text searching, interactive question-answering, fact retrieval, data displays, and information regeneration for knowledge transfer networks.

Educational opportunities

The center is closely affiliated with the Division of Information Science within the department of philosophy (see course listing). Programs leading to the M.S. and Ph.D. degrees are offered by the division. In addition, the division cooperates with the departments of mathematics, electrical engineering, and industrial engineering in supporting the master's degree program in computer science.

In both the M.S. and Ph.D. programs in information science, considerable emphasis is placed on mathematics, computer programming, computer languages, statistics, electrical engineering, psychology, sociology, and management science. This widespread involvement of different disciplines is necessitated by the eclectic nature of information science.

For further information write to the director, Professor D. J. Hillman, Mart Library, Lehigh University, Bethlehem, Pa. 18015.

Center for Marine and Environmental Studies

Background and purposes

Effective utilization of the resources of the oceans requires the cooperation of many scientific and engineering disciplines. Practical solutions for the many critical environmental problems facing the world will most likely be achieved through a combination of engineering and scientific talent. The Center for Marine and Environmental Studies (CMES) was established in 1962 to foster a multidisciplinary approach to research on these broad problem areas. The staff of the center includes faculty and graduate students from the departments of biology, chemical engineering, chemistry, civil engineering, economics, geological sciences, mechanical engineering and mechanics, and physics.

A good marine scientist is one well-trained in a classical field of science, i.e., biology, chemistry, geology, or physics, who can apply the principles of that discipline to the understanding of complex interacting systems in the oceans. A good ocean engineer is one well-trained in a traditional engineering discipline who can apply engineering principles to problems unique to operations in the ocean. An environmental scientist or engineer needs a broad background in many disciplines, as environmental problems are invariably interdisciplinary in nature. CMES seeks to provide research opportunities in these fields and to assist faculty and graduate students in applying their academic training and experience to the acquisition of new knowledge and to the solution of real problems.

Research activities

The Center for Marine and Environmental Studies includes a broad spectrum of research activities. Some of the research in marine science and environmental studies is performed at the off-campus seashore facility of the center, The Wetlands Institute, located near Stone Harbor, N.J. (see listing in this section under institutes). Through informal cooperation with other institutions having oceanographic facilities and ships, the staff and students affiliated with CMES have a variety of opportunities for experience and work at sea.

Current research activities indicate present interests of CMES staff and include:

Marine science. Coastal salt marsh ecosystems; sublethal effects of pollutants on key marine organisms in the food chain; immunological methods for fish egg identification; biological effects of thermal pollution; biochemistry of proteolytic marine bacteria; fate of fatty acids in mangrove swamps; fine grained sediment accumulation on a deep sea fan; deformation of near-surface sediments at a subducting continental margin; shallow water near shore and estuarine sedimentation; impact of volatile components of oil on marine organisms.

Ocean engineering (Marine Geotechnical Laboratory). Development of geotechnical instrumentation for use at sea; in-place measurement of geotechnical properties of sea floor soils, both deep water cohesive soils and continental shelf sandy soils; slope stability studies; factors affecting development of shear strength in cohesive marine soils.

Environmental studies. Effects of industrial and municipal pollution on streams and rivers; advanced waste water treatment methods; heavy metals in dredge spoils; biological regeneration of activated carbon; fluidized bed reactors for improved utilization of immobilized enzyme catalysts.
Environmental dynamics. General atmospheric circulation; development of fronts in the atmosphere; dynamics of squall lines, thunderstorms and tornados; tsunamis; earth bow shock structure.

Educational opportunities

Graduate students participating in the center's programs usually receive M.S. or Ph.D. degrees from traditional academic departments, i.e., biology, chemistry, geological sciences, civil engineering, etc. Thesis or dissertation research required for the advanced degree may be performed within the framework of the research activities of the center. The program of courses to meet the student's special field of interest and to satisfy departmental and graduate school requirements is arrived at by consultation with the academic department chairman or a special Ph.D. committee.

Courses in marine science, i.e., biological oceanography, marine geology, ocean physics, etc., are offered by the appropriate academic departments. Ocean engineering courses are offered in the civil engineering department. Courses related to environmental studies are offered in the departments of biology, chemistry, chemical engineering, civil engineering, and geological sciences.

Further information concerning educational opportunities may be obtained from the chairman of the prospective major department, or from the director of the center, Professor James M. Parks, Williams Hall, Lehigh University, Bethlehem, Pa. 18015.

Center for Surface and Coatings Research

Background and purpose

The Center for Surface and Coatings Research was founded in 1966 in acknowledgment of the fact that surfaces and coatings are of basic scientific interest and technological importance. Research in surface chemistry was initiated at Lehigh in the early 1940s and was broadened into the field of chemical coatings in 1946 when the National Printing Ink Research Institute began its activities at Lehigh.

The purpose of the center is to make a coordinated, continuous, and competent effort to understand complex surface and coating phenomena. Almost every aspect of life involves a surface; surfaces are rarely bare, except in an ultra-high vacuum, but are usually covered with a coating from the atmosphere or from a prior treatment. An understanding of the properties of surfaces and the accidentally—or purposely—applied coating is vital to the semiconductor, chemical, petroleum, metals, and ink industries.

Thirteen faculty members from the departments of chemistry, chemical engineering, and mechanical engineering and mechanics are associated with the center, ten of whom have offices in the 36,000-square-foot Sinclair Laboratory, completed in December 1970. This close interaction has enabled the center to be truly interdisciplinary in outlook and in fact.

Financial support for the center comes largely from research projects contracted with various industrial and governmental agencies. Opportunities for cooperative sponsorship are provided by the center's liaison programs, whereby fundamental nonproprietary research is performed in areas of specific interest to the participating sponsors. Current liaison programs are concerned with surface and coatings science and emulsion polymerization. A Laboratory for Color Science is also cooperatively supported.

The center is particularly well equipped with specialty instrumentation needed for advanced research. Sinclair Laboratory houses equipment for experimental studies employing electron spin resonance, ferromagnetic resonance, flash desorption, Mossbauer spectroscopy, Auger spectroscopy, nanosecond fluorescence spectroscopy, ellipsometry, and computerized spectrophotometry. Other specialty equipment includes microbalances, a materials testing machine, gas adsorption and heat of immersion apparatus, wetting balances, 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: theoretical studies of aluminosilicate complexes; zeolites; optical, fluorescence, and magnetic spectroscopy of surfaces; ice formation on low energy nucleants; wetting in multiphase systems; wetting of high and low energy sur-

faces; characterization of surfaces by gas adsorption; microelectrophoresis; computerized color matching; estimation of color differences; color constancy and metamerism in coatings; light scattering by microvoids; Mossbauer spectroscopy of surfaces; passivity and corrosion inhibition; Auger spectroscopy of surfaces; environmentally affected crack growth in metals; hydrogen embrittlement; adhesion of coatings; corrosion under coatings; electrodeposition of intermetallic compounds; water-based coatings; polymer surfaces; catalysis; rate of drying of latex films; surface characterization of latexes; preparation of latexes by direct emulsification; particle size determination by hydrodynamic chromatography; rheology in non-Newtonian fluids; and adhesion and flow of fluids on porous substrates.

The *Journal of Colloid and Interface Science* and *Advances in Colloid and Interface Science* are edited by a faculty member associated with the center.

Educational opportunities

CSCR is a facility in which graduate students undertake dissertation research leading to the M.S. or Ph.D. degree in existing science and engineering curricula. Pertinent courses are offered in the departments of chemistry, chemical engineering, physics, mathematics, biology, metallurgy and materials science, and mechanical engineering and mechanics. A formal program in polymer science has been proposed.

Potential and current graduate students whose interests are consistent with the center's objectives are welcome to associate with the research program and to avail themselves of the experimental facilities. Research assistantships are available. Since research topics are selected by mutual agreement, interested students are encouraged to explore research opportunities with the center's director.

The center's research also forms the basis of continuing educational programs designed primarily for industrial personnel. The conference center in the Sinclair Laboratory is ideally suited for the special seminars and short courses held periodically. Recent course topics include surface analysis, printing ink technology, emulsion polymerization, computer formulation of colorants, and paint removal.

The center provides opportunities for resident postdoctoral studies and for visiting scientists.

For further information, write to the director, Professor Henry Leidheiser, Sinclair Laboratory, Lehigh University, Bethlehem, Pa. 18015.

Center for Social Research

Background and purpose

The Center for Social Research (CSR) is a multidisciplinary organization designed to stimulate, conduct, and communicate the results of research involving the social and behavioral sciences, particularly in relation to a technological perspective. Several disciplines are involved in the activities of CSR: economics, political science, psychology, sociology, international relations, industrial engineering, and electrical engineering. Through externally funded projects, CSR also cooperates with the university's other research centers, such as Fritz Laboratory, the Computing Center and the Center for Marine and Environmental Studies.

Founded in 1965 as the Center for Business and Economics, the focus of CSR was later broadened and the name changed to the Center for Business, Economics, and Urban Studies. The center's early activities included research on economic 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, CSR's scope was further broadened to include behavioral science and international affairs and the center's present name was selected as more accurately reflecting this broadened focus.

Research activities

CSR's current programs of research and development cover the following five broad areas: *Behavioral Research*, which includes members of the departments of government, history, social relations, and industrial engineering; *Business and Economics* which includes members of the departments of economics, accounting, and management and finance; *International Studies*, which includes faculty from the departments of international relations, psychology, biology, geology, economics, chemistry, government, and the centers for information science and marine and environmental science and the Institute for Pathobiology; *Manpower*, which includes faculty from the departments of economics, government, psychology, industrial engineering, and social relations and from the

School of Education; and *Urban Studies*, which includes faculty from the departments of government, social relations, economics, and industrial engineering.

Interdisciplinary research activities are currently in the following areas:

Telecommunications policy involves the investigation of policy and the development of policy alternatives and ways to test their potential impacts on the cable television industry and on society. Particular attention is devoted to establishing a strong capability for research on telecommunications policy.

Evaluation of social service delivery includes the development of computerized systems for maintaining client records in social service agencies and the conduct of evaluations of social service delivery systems in areas such as mental and physical handicaps, adolescent problems and child abuse. Emphasis is on the development of means for evaluating social service delivery.

International science and technology affairs focuses on the development of understanding of technology assessment on an international scale. One project in this area is a series of seminars and courses on the international policy-making implications of science and technology.

Urban Policy Analysis involves analysis of how cities can better support technology in areas such as high-rise building development through such services as transportation, police and fire control, land use planning, sanitation, and water supply.

Social and psychological impacts of built environments focuses on the study of behavioral responses to manmade environments, such as high-rise buildings. Emphasis is on the development of theory and method relevant to this area of study.

The social perspective of CSR's research activities makes them relevant to many facets of activity outside the university in local, regional, national and international affairs. Many research activities are based on a cooperative university-community relationship through which the research goals of CSR are achieved and community needs met.

Educational opportunities

All faculty associates of CSR are members of university academic departments and teach in their respective departments. Graduate and undergraduate students from these departments are active in the center's research activities. These departments in most cases offer graduate degrees at the master's level and a few offer the doctorate.

Faculty from CSR have participated in the Department of Health, Education and Welfare-supported two-year project, "International Science and Technology Affairs," which is specifically designed to develop seminars and courses in the area of policy-making related to science and technology.

CSR is associated with the Urban Studies graduate program which provides interdisciplinary training in urban processes. Depending upon interest and choice of courses, students will be prepared for careers in city management, urban planning and redevelopment, human relations and social rehabilitation. Master's degree candidates work within the disciplines of economics, government, history or social relations. (See urban studies division for recommended combinations of individual department course offerings and graduate advisors.)

Financial assistance to graduate students is available through graduate research assistantships provided by research grants and contracts to CSR.

For further information contact the director, Roy C. Herrenkohl, Center for Social Research, Lehigh University, Bethlehem, Pa. 18015.

Fritz Engineering Laboratory

Background and purpose

Founded in 1909, the Fritz Engineering Laboratory serves for the advancement of knowledge and techniques in the fields of structures, structural mechanics, materials, hydraulics and fluid mechanics, soil mechanics, and sanitary engineering.

Fritz Laboratory is associated primarily with the department of civil engineering. In addition, there are cooperative research efforts with other departments of the University and with other institutes and universities. Research projects are sponsored through the Office of Research by national research councils, mechanics, soil mechanics, and sanitary engineering agencies.

Graduate studies combined with research investigations commenced at Fritz Laboratory in 1928. A major expansion of the facilities in 1955 has been followed by addition of the necessary equipment to meet the needs of new research opportunities.

The staff of the laboratory consists of faculty members, research associates, research assistants, and

supporting technical personnel. The laboratory awards research assistantships and certain fellowships to competent research personnel who are candidates for advanced degrees. Students from departments and divisions such as civil engineering, metallurgy, mechanics and mechanical engineering and information science are able to take advantage of research opportunities with the laboratory. Through their work in research programs, individuals are trained for careers in teaching, in research, and in advanced engineering design.

Research activities

The current research divisions indicate present interests and activities of the laboratory staff and include the following: fatigue and fracture (brittle failure due to cyclic and impact loading); geotechnical engineering (soil, foundation, rock and pavement mechanics); hydraulics and sanitary engineering (stream and channel flow, hydrology, sediment transport in pipes and channels, water quality control, water resources, and waste water treatment); building systems (behavior and strength of building components, frames and over-all systems, problems involved in the design of high-rise buildings, earthquake and wind responses); structural concrete (prestressed and reinforced concrete bridges and buildings); structural connections (welded and bolted joints, composite structures); and structural stability (buckling of plates, beams, columns and frames). The operations division provides services for laboratory work, and includes an instrumentation group and a computer systems group, the latter maintaining close liaison with the University CDC 6400 facility.

As a result of the research studies conducted by the staff of the laboratory, it has been possible to make basic changes to design procedures and specifications in numerous specialty fields. The laboratory participates in a worldwide exchange of research information, maintains a special library of technical papers appropriate to its fields, and stimulates the publication of papers in technical journals both in this country and abroad.

Educational opportunities

Through the laboratory organization, technical seminars and lectures are presented on current research findings and on new design applications in the various fields of civil engineering and related disciplines.

Courses students select are primarily in the department of civil engineering; however, to gain a broader understanding, many students choose courses from the departments of biology, chemical engineering, chemistry, geological sciences, mechanical engineering and mechanics, and metallurgy and materials science.

For further information write to the director, Professor Lynn S. Beedle, Fritz Laboratory, Lehigh University, Bethlehem, Pa. 18015.

Materials Research Center

Background and purpose

The Materials Research Center was established in 1962 to fulfill the need for a research and educational facility permitting intellectual stimulation of faculty and students dedicated to research in materials. Currently, approximately 180 persons, including graduate students 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, 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 semiannual day seminars on materials research, special lectures, consultation on materials problems and research, distribution of all M.S. and Ph.D. thesis abstracts on materials research, and monthly seminars with outstanding invited speakers.

The staff consists of members of the departments of chemistry, chemical engineering, electrical engineering, mechanical engineering and mechanics, metallurgy and materials science, and physics. Members of other departments and centers frequently are involved in cooperative programs. Communication with these associated units is achieved through the Materials Research Council, which is composed of senior faculty members from all of the engineering departments as well as from the department of geological sciences and appropriate centers. The council serves in an advisory capacity as well as a channel for information.

Research activities

The present organization of the Materials Research Center, located at the Coxe Laboratory, includes four laboratories, the advanced materials laboratory, ceramics research laboratory, mechanical behavior laboratory, and polymer laboratory.

Current interdisciplinary research activities include:
Advanced materials. Characterization of metal oxide films; defect structure of amorphous and crystalline materials in both bulk and thin film form; diffusion kinetics; eutectic research including solidification, microstructure, and property studies; preparation and properties of materials for solid state devices; processing of metal-insulator-semiconductor structures and their evaluation and application to integrated circuits; structure and properties of sputtered and evaporated thin films.
Ceramics. Mechanical behavior of ceramic materials such as strength, elastic properties, static and cyclic fatigue, thermal stress fracture and thermal fatigue, fracture toughness and crack propagation behavior. Synthesis and mechanisms of wear of ceramic cutting-tool materials. Thermal conductivity and diffusivity of engineering ceramics.
Mechanical behavior. Effect of complex load interactions on fatigue crack propagation (FCP); deformation, fatigue and creep rupture response of eutectic composites; FCP of polymeric materials; fracture characteristics of bridge steels; metallurgical aspects of fatigue behavior in engineering alloy systems; fracture mechanism studies by transmission and scanning electron microscopy.
Polymers. Fatigue and relaxation processes in engineering plastics; morphology and mechanical behavior of interpenetrating networks; constrained-layer damping systems; structure, morphology, and mechanical behavior of polyvinyl chloride; reinforcement of elastomers and thermoelasticity; permeability and mechanical behavior of coatings and membranes, strengthening mechanisms in polymer-modified concrete.

Educational opportunities

This center facilitates interdisciplinary 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 M.S. or Ph.D. degrees in the traditional discipline of their choice, i.e., chemistry, physics, metallurgy and materials science, electrical engineering, etc.; however, they are expected to pursue course work related to a broader understanding of materials and conduct research on an interdisciplinary materials problem in one of the four center laboratories. A special program leading to an M.S. in materials is described in the section on Special Academic Opportunities.

Financial support for graduate students is available through the Materials Research Center by means of industrial fellowships as well as fellowships provided from the operating funds of the center, and by research assistantships related to sponsored research programs.

For further information write to the director, Professor Donald M. Smyth, Coxe Laboratory, Lehigh University, Bethlehem, Pa. 18015.

Other organizations

A description of the university's institutes appears immediately following the course listings in the next section. A description of research organizations appears on page 56.

Registration Statistics

	spring 1972	summer 1972	fall 1972	spring 1973	summer 1973	fall 1973	spring 1974	summer 1974	fall 1974
undergraduates	3,306	448	3,592	3,454	461	3,872	3,683	466	3,960
graduate students	1,898	1,464	2,037	2,005	1,519	2,191	2,094	1,659	2,141
special students	38	15	34	33	8	38	30		34
totals	5,242	1,927	5,663	5,492	1,988	6,101	5,807	2,125	6,135

Spring, 1972	*Sr.*	*Jr.*	*Soph.*	*Fresh.*	*Total*
Arts and Science	227	250	281	360	1,118
Arts and Engineering	14	14	17	35	80
Business and Economics	141	158	169	159	627
Chemical Engineering	45	47	48		140
Chemistry	27	12	21		60
Civil Engineering	40	47	47		134
Electrical Engineering	63	61	74		198
Engineering Mechanics	5	2	3		10
Engineering Physics	13	6	8		27
Fundamental Science	13	12	14		39
Industrial Engineering	44	34	32		110
Mechanical Engineering	49	49	54		152
Metallurgy and Materials Science	17	35	30		82
Unclassified Engineers		13	31	463	507
total	698	740	829	1,017	3,306*

*includes 22 in General College division.

Fall, 1972	*Sr.*	*Jr.*	*Soph.*	*Fresh.*	*Total*
Arts and Science	228	279	358	406	1,271
Arts and Engineering	20	11	15	20	66
Business and Economics	145	199	193	181	718
Chemical Engineering	49	46	78	1	174
Chemistry	13	20	13		46
Civil Engineering	55	51	92	1	199
Electrical Engineering	60	72	85		217
Engineering Mechanics	2	3			5
Engineering Physics	7	16	12		35
Fundamental Science	12	15	20		47
Industrial Engineering	36	35	34	2	105
Mechanical Engineering	48	57	70		175
Metallurgy and Materials Science	36	25	23		84
Unclassified Engineers		15	25	372	412
total	711	844	1,018	981	3,592*

*includes 38 in General College division.

Spring, 1973	*Sr.*	*Jr.*	*Soph.*	*Fresh.*	*Total*
Arts and Science	282	265	308	365	1,220
Arts and Engineering	25	7	9	14	55
Business and Economics	165	182	196	174	717
Chemical Engineering	51	48	62		161
Chemistry	16	16	13		45
Civil Engineering	56	65	79		200
Electrical Engineering	72	72	66		210
Engineering Mechanics	2	3	–		5
Engineering Physics	9	17	7		33
Fundamental Science	14	14	14		42
Industrial Engineering	41	31	36		108
Mechanical Engineering	58	54	55		167
Metallurgy and Materials Science	35	28	15		78
Unclassified Engineers		3	35	329	367
total	826	805	895	882	3,454*

*includes 46 in General College division.

Fall, 1973	*Sr.*	*Jr.*	*Soph.*	*Fresh.*	*Total*
Arts and Science	249	318	353	403	1,323
Arts and Engineering	23	9	5	34	71
Business and Economics	192	219	244	196	851
Chemical Engineering	45	57	53		155
Chemistry	24	19	11		54
Civil Engineering	62	82	74	1	219
Electrical Engineering	79	73	73		225
Engineering Mechanics	4	–	3		7
Engineering Physics	12	7	4		23
Fundamental Science	11	17	12		40
Industrial Engineering	34	38	31		103
Mechanical Engineering	65	58	70		193
Metallurgy and Materials Science	28	18	9		55
Unclassified Engineers	1	5	41	420	467
total	829	920	983	1,054	3,872*

*includes 86 in General College division.

Spring, 1974	*Sr.*	*Jr.*	*Soph.*	*Fresh.*	*Total*
Arts and Science	294	279	284	377	1,234
Arts and Engineering	20	5	4	31	60
Business and Economics	201	223	239	196	859
Chemical Engineering	49	62	48		159
Chemistry	25	24	13		62
Civil Engineering	69	76	71	216	
Electrical Engineering	83	66	64	1	214
Engineering Mechanics	2	1	2		5
Engineering Physics	16	3	3		22
Fundamental Science	17	15	7		39
Industrial Engineering	37	35	33		105
Mechanical Engineering	62	54	64		180
Metallurgy and Materials Science	30	12	9		51
Unclassified Engineers		2	41	371	414
total	905	857	882	976	3,683*

*includes 63 in General College division.

Fall, 1974	*Sr.*	*Jr.*	*Soph.*	*Fresh.*	*Total*
Arts and Science	275	268	370	411	1,324
Arts and Engineering	10	2	8	24	44
Business and Economics	185	277	282	188	932
Chemical Engineering	53	56	53		162
Chemistry	19	20	11		50
Civil Engineering	81	80	96		257
Electrical Engineering	66	60	93		219
Engineering Mechanics		2	1		3
Engineering Physics	6	1	1		8
Fundamental Science	18	10	8		36
Industrial Engineering	38	41	31		110
Mechanical Engineering	53	72	74		199
Metallurgy and Materials Science	21	10	20		51
Unclassified Engineers		11	35	456	502
total	825	910	1,083	1,079	3,960*

*includes 63 in General College division.

all figures are for fall

Geographical distribution of undergraduate students

	1972	*1973*	*1974*
Alabama	3	4	3
Arizona	1	1	1
California	15	12	8
Colorado	5	6	7
Connecticut	120	131	149
Delaware	18	14	19
District of Columbia	6	7	12
Florida	18	24	25
Georgia	8	7	9
Hawaii	–	1	1
Idaho	–	1	–
Illinois	20	10	12
Indiana	4	2	3
Kansas	–	–	1
Kentucky	4	3	2
Louisiana	1	3	4
Maine	2	1	1
Maryland	101	98	89
Massachusetts	55	66	73
Michigan	5	9	9
Minnesota	–	4	4
Mississippi	2	3	3
Missouri	1	3	4
Montana	–	–	1
Nebraska	2	2	1
New Hampshire	9	8	5
New Jersey	856	933	1,016
New Mexico	1	–	–
New York	513	586	568
North Carolina	3	6	5
Ohio	39	40	37
Oklahoma	1	1	–
Oregon	–	–	1
Pennsylvania	1,678	1,784	1,771
Rhode Island	7	6	5
South Carolina	2	3	1
Tennessee	2	1	1
Texas	9	5	8
Utah	–	1	–
Vermont	2	2	2
Virginia	16	15	19
Washington	–	–	2
West Virginia	2	1	1
Wisconsin	3	4	5
Argentina	1	–	–
Arabia	1	–	–
Belgium	1	2	2
Bermuda	1	–	–
Brazil	2	1	2
Cameroon	1	–	–
Canada	–	1	1
Chile	1	–	1
Colombia	3	3	3
Dominican Republic	1	1	–
Ecuador	1	1	1
France	1	2	5
Germany	2	–	2
Ghana	–	1	–
Greece	1	2	4
Guatemala	–	1	1
Holland	–	1	–
Honduras	1	1	1
Hong Kong	8	5	7
Iceland	–	1	–
India	–	–	2
Iran	6	9	10
Ireland	1	–	2
Italy	2	1	1
Japan	1	–	–
Kuwait	1	1	2
Lebanon	1	1	4
Liberia	1	–	1
Malaysia	1	–	–
Mexico	2	3	3
Netherlands	1	–	1
Nicaragua	1	1	1
Nigeria	1	1	–
Norway	1	–	–
Panama	2	3	2
Peru	2	2	–
Puerto Rico	1	2	1
Sweden	–	1	1
Switzerland	–	–	1
Thailand	3	3	3
United Kingdom	–	1	1
Venezuela	3	4	3
Vietnam	1	1	1
West Germany	–	2	–
Virgin Islands	–	–	4
totals	3,592	3,872	3,960

5

Course Descriptions

General information

Following is a list 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.

Credit hours

The number in parentheses following each course title indicates the credit value of the course in terms of semester hours. Three hours of drawing, of work in the laboratory, or of practice in the field are regarded as the equivalent of a recitation or lecture of one hour's duration.

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. The numbering series is as follows:
0-99 Undergraduate courses, primarily for underclassmen. Not available for graduate credit.
100-199 Advanced undergraduate courses. Not open to freshmen except on petition. Not open to sophomores except on petition, unless part of major program or curriculum. Not available for graduate credit.
200-299 Courses open to advanced undergraduates and graduates. Not available for graduate credit in the major field.
300-399 Courses open to advanced undergraduates and graduates. Available for graduate credit in the major field.
400-499 Courses open to graduate students only, and undergraduates by special petition.

High Immediate Relevance Courses

Each instructional department is authorized to offer High Immediate Relevance courses—courses based on contemporary social and scientific issues—within a semester, with the option of having them become a permanent part of the University curriculum. HIR courses will be numbered, as is appropriate, ...97-98, ...197-198, ...297-298, ...397-398, for a maximum of two semesters.

Students may take 97-98 HIR courses Pass/Fail under the standard procedures for Pass/Fail.

Apprentice teaching

Apprentice teaching is designed for advanced students, normally in their senior year, who wish to learn about teaching under the guidance of an experienced teacher. Master and apprentice teachers are, with the approval of the chairman of the department in which the apprentice teaching is to be done, free

for the most part to work out whatever arrangements best fit the needs of the course.

Apprentices typically receive three hours of credit for attending classes, doing some lecturing or leading of discussion sections, assisting in making up or grading some written assignments and tests, and being available for some individual consultation with students. A student may register for apprentice teaching only once each semester, and only twice for credit in his or her college career, for a total of not more than six hours of credit. The student may register to be an apprentice teacher in a given course only once. A graduate student who is not a paid teaching assistant may register for apprentice teaching, but the department must decide whether the student may receive credit which will count toward fulfilling requirements for a graduate degree. The apprentice will be graded for work in the course by the master teacher.

Students who wish to do apprentice teaching in extra-departmental courses, such as those offered as Freshman Seminars or Creative Concepts courses, may do so with the approval of the director of the program. In High Immediate Relevance courses or courses cross-listed in several departments, the approval of the chairman of that department in which the course is taught will be required. In such cases, the student will be registered for the 300 course with the same heading as the course in which he or she is an apprentice (e.g., FS 300—Apprentice Teaching in FS 97C; CC 300—Apprentice Teaching in CC 101A; HIR 300—Apprentice Teaching in HIR 197, or as a departmental 300 course if the HIR course is given as a departmental offering).

Prerequisites

Academic preparation required for admission to courses is indicated under "Prerequisites" following course descriptions stated in most cases for purposes of convenience in terms of Lehigh courses. 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 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 by the Registrar a waiver of prerequisites signed by the head of the teaching department, and the student's curriculum director. 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.

English 2, 10, 14, or 16 shall be prerequisite to all 100- or higher-level courses: exceptions may be made only by petition to the Committee on Standing of Students.

Understanding abbreviations

Wherever 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. While all information in this catalog is subject to change, the information is included to help guide the student in the selection of appropriate courses that best fulfill his or her academic and personal requirements.

The symbols following course titles for some Arts and Science courses include:

P — Courses that meet preliminary distribution requirements.

PU — Courses that meet preliminary or upperclass distribution requirements.

NS — Psychology department courses that meet the Natural Science distribution requirements. Any psychology course not so designated is understood to meet Social Science distribution requirements.

Whenever possible, the name of the instructor scheduled to teach the course is included at the end of the entry. No professor is listed in cases where several members of the staff may be chosen to teach the course, or where the professor has not been designated at this writing.

Accounting

Professors

Robert H. Mills, Ph.D., C.P.A., *Chairman*
Alfred P. Koch, M.S., C.P.A.
Carl L. Moore, M.S., C.P.A.
James B. Hobbs, D.B.A.

Associate Professor

Feng-Shyang Luh, Ph.D.

Assistant Professor

Kenneth P. Sinclair, Ph.D.

Instructors

George H. Bodnar, B.S.
Stuart K. Webster, M.B.A., C.P.A.
Dunham R. Bainbridge, M.S., C.P.A.
Dale R. Martin, M.S.
John W. Paul, M.B.A., C.P.A.

Major in Business and Economics College

Required: 15 credits beyond the core requirements.

Acctg 315	Financial Accounting I (3)
Acctg 316	Financial Accounting II (3)
	Accounting Electives (except Acctg 390) (9)

Note: Students interested in qualifying for Certified Public Accountant or the Certificate of Management Accounting at either the bachelor or M.B.A. level should consult the chairman of the department of accounting or their major advisor.

Undergraduate Courses

51. Essentials of Accounting (3) fall-spring
The organization, measurement and interpretation of economic information. Introduction to accounting theory, concepts and principles, the accounting cycle, and information processing. Exposure to controversial issues concerning income determination and valuation. Prerequisite: sophomore standing.

52. Essentials of Accounting (3) fall-spring
Financial statement analysis for managerial and external use. The use of economic information for managerial planning and control. Introduction to job order, process, and standard cost accounting, variable costing, and volume-mix-price-cost relationships. Prerequisite: Acctg. 51 or 108.

108. Fundamentals of Accounting (3) fall-spring
A one-semester survey of accounting principles and practices, including an introduction to industrial cost systems designed primarily for those students planning to take only one accounting course. Other students should take the Acctg. 51, 52 sequence.

111. Computers in Business (3) fall-spring
An introduction to computers with emphasis on business applications. Develop a working knowledge of a computer language sufficient to solve business problems. Basic knowledge of hardware, software, error control, integrated systems, and simulation. Not open to students who have had a previous equivalent (normally three credit hours) course in computers.

For Advanced Undergraduates and Graduates

300. Apprentice Teaching in Accounting (1-3)

307. Federal Tax Accounting (3) fall-spring
An interpretation of the federal income tax laws, rules, and regulations applicable to income tax determination of individuals, partnerships, and corporations. Tax planning and timing of transactions is emphasized. Prerequisite: Acctg. 51 or 108. Mr. Koch.

311. Accounting Information Systems (3) fall
A general introduction to the development and implementation of an electronic data processing accounting information system. The course will consider the tools and techniques used by someone performing the systems function. Prerequisite: Acctg. 52 or 108 and Acctg. 111. Mr. Luh.

315. Financial Accounting I (3) fall
Intensive study of the basic assumptions and principles of accounting, the accounting process, and problems concerned with presenting fairly the financial position and operating results of business entities. Consideration of the measurement of current assets, current liabilities, non-current assets, long-term debt, and preparation of financial statements. Prerequisite: Acctg. 51 or 108. Messrs. Bainbridge and Webster.

316. Financial Accounting II (3) fall-spring
A study of generally accepted accounting principles and problems concerned with presenting fairly the operating results, financial position and changes in financial position of business entities. Consideration of shareholders, equity, partnerships, earnings per share, tax allocation, pensions, leases, and price level changes. Preparation, analysis, and interpretation of financial statements. Prerequisite: Acctg. 51 or 108. Messrs. Bainbridge and Webster.

317. Advanced Accounting (3) spring
Problems of business combinations and consolidations, fund accounting as it applies to not-for-profit entities, foreign exchange, and fiduciary accounts. Prerequisite: Acctg. 315 or 316. Mr. Luh.

318. Contemporary Issues (3) spring
Intensive study of American Institute of Certified Public Accountants pronouncements, research studies, cases, re-

ports, related to current external reporting problems in public accounting. Prerequisite: senior standing or consent of chairman. Mr. Webster.

320. Auditing (3) fall
Survey of auditing theory, objectives, and practices relating largely to the responsibilities of independent professional accountants; ethics of the profession, generally accepted auditing standards, internal control, examination of various systems including EDP, statistical methods, report writing, etc. Prerequisite: Acctg. 315. Mr. Paul.

324. Cost Accounting (3) spring
Principles and practices of industrial cost accounting, including cost planning and budgeting, cost controls, job-lot and standard and process systems, variance analysis, performance reports, costs in management decisions. Prerequisite: Acctg. 52 or 108.

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 chairman.

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

390. Internship (3-6)
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 will be assigned. Written reports will be submitted by employer and students. The amount of credit will be influenced by the length of the training period and the character of the experience afforded to the trainee, but will not exceed six hours for a regular semester or three hours for a summer period of at least eight weeks. Prerequisite: junior standing and approval of faculty committee on internship.

For Graduates

The specialized accounting courses at the 300 level are frequently offered in graduate sections in addition to the 400-level courses. These graduate offerings permit Master of Business Administration students to take a limited concentration of 9-12 hours in accounting. If they have taken 12 to 15 hours in accounting as undergraduates, their total professional preparation of 21-27 hours represents a sound basis for a career in public, industrial or governmental accounting. Undergraduates may wish to plan ahead for a full five-year program including the master's degree for professional accounting preparation. (Note that Acctg. 422, Managerial Accounting, is for non-accounting major MBA students and not open for credit to master's candidates who majored in accounting as undergraduates or who are carrying an accounting field of specialization at the graduate level.) For further information about CPA requirements in different states, CMA certificate, or for the selection of accounting electives, see the chairman, accounting department.

406. Advanced Tax Planning & Research (3) spring
An advanced course in federal tax laws, rules, and regulations involving cases and problems relating to various tax entities. Tax planning and utilization of research tools is emphasized. Prerequisite: Acctg. 307. Mr. Koch.

408. (I.E. 408) Management Information Systems (3)
For description, see I.E. 408.

422. Managerial Accounting (3) fall
Survey course for non-accounting majors (related course for accounting majors is Acctg. 324); uses of accounting data for managerial planning and control, including cost control; capital expenditure planning; product pricing decisions; operations research applications. Prerequisite: Acctg. 51 or 108. Mr. Moore.

424. Advanced Management Accounting (3) spring
Managerial planning and control problems with emphasis on the responsibilities of the accountant. Practical applications using cases. Includes advanced treatment of management control systems, managed costs, transfer pricing, and the capital investment problem. Prerequisite: Acctg. 324 or 422. Messrs. Luh and Sinclair.

426. Advanced Problems (3) spring
Advanced problems and cases in the formation, transfer of ownership interests, operation, and liquidation of various forms of business entities; government accounting; foreign exchange. Prerequisite: Acctg. 315, 316 and permission of chairman. Mr. Moore.

431. Accounting Theory and Thought (3) fall
A critical and historical examination of modern accounting concepts. Concerned with measuring enterprise income and capital and related economic data, in both simplified and realistic circumstances, and with communicating and interpreting such data effectively to interested parties. Prerequisite: 15 hours of accounting.

442. Professional Accounting Seminar (3) spring, alt. years
Survey of technical and professional accounting problems at the advanced level. Advanced case studies in public accounting and management services. Prerequisite: 15 hours of accounting.

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

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

Aerospace Studies

Professor

Colonel Lawrence Hasbrouck, M.B.A., *Chairman*

Assistant Professors

Captain Vincent A. Ziccardi, M.B.A.
Captain John A. Fratto, M.B.A.
Captain John H. Fergus, Jr., M.S.

Assistants

Technical Sergeant Phillip A. Summers
Staff Sergeant David J. Adkins
Staff Sergeant Gregory B. Wilson

The Air Force Reserve Officers Training Corps (AFROTC) program at Lehigh University was established in October, 1946. The program is conducted through the department of aerospace studies, which offers two voluntary programs for students to qualify for commission as a second lieutenant in the Air Force: one of four years and one of two years. Any student who will meet the baccalaureate degree requirements at the end of the university education may enroll in the four-year program or apply for entry into the two-year program. Students in the advanced Air Force ROTC courses receive a $100 monthly tax-free subsistence allowance. Students must complete their AFROTC training and university education and be commissioned by their twenty-eighth birthday.

The general objective of the Air Force program is to instill in each student: (1) a basic understanding of associated professional knowledge; (2) a strong sense of personal integrity and individual responsibility; (3) an appreciation of the requirements of national security; and (4) an opportunity to learn and develop leadership ability.

Course Credit. Aerospace Studies course credit may be substituted for six hours of electives for students in the College of Arts and Science and the College of Business and Economics. In the College of Engineering and Physical Sciences, six credits of advanced ROTC work will be included within the normal program of each student, irrespective of his or her curriculum. For curricula which include more than six hours of personal electives in the junior and senior years, inclusion of more than six hours of advanced ROTC credit within normal programs can only be effected with the approval of academic advisors.

Four-Year Program. The four-year program consists of classroom and laboratory work during the four undergraduate years and a field training period of four weeks, usually between the junior and senior years, at an Air Force base.

During the first two years, the program acquaints students with aerospace technological advances and current research and development activities. Students also begin leadership training. During the last two years, emphasis is placed on personal development. Students practice leadership talents and ability by assuming positions of responsibility in the Cadet Corps.

Two-Year Program. All requirements for commissioning can be completed in the two-year program. Students may apply for entry not later than March of their sophomore year. This program is also available to select graduate students, on a limited basis, who have two full years of academic study remaining at Lehigh. Prior to formal enrollment, each student must successfully complete six weeks of field training at an Air Force base.

Scholarship Program. Air Force ROTC awards scholarships at the freshman, sophomore, and junior levels. They are available to qualified cadets in the two-year and four-year programs. Once awarded a scholarship, a cadet continues on scholarship status until graduation. These scholarships cover full tuition, laboratory expenses, incidental fees, and books. Scholarship cadets also receive a $100 monthly tax-free subsistence allowance.

Flight Instruction Program. Senior cadets who are physically qualified may take flight instruction in their senior year at no cost to themselves. The FIP provides twenty-five hours of flying time (seventeen hours dual and eight hours solo). Cadets who complete the twenty-five hours of instruction, and go on to pass the Federal Aviation Administration written examination and the final flight check, may receive an FAA private pilots license.

Airborne Training Program. Appropriate classroom, physical conditioning, and airborne parachute training (including five controlled parachute jumps) is available through a cooperative Air Force/Army program. Aerospace Studies students volunteering for this specialized course of instruction spend approximately three weeks at an active military installation during the summer preceding their senior year.

Field Training. Two field training courses are offered. One course covers four weeks for cadets in the four-year program, and the other covers six weeks for two-year applicants.

Cadets normally attend the four-week course after their sophomore year. Candidates for the two-year program must successfully complete the six-week course before they enter the Professional Officer Course.

The six-week course includes substantial classwork in "United States Military Forces in the Contemporary World." Both courses include orientation, survival training, junior officer training, aircraft and aircrew orientation, physical training, small arms marksmanship training, organization and function of an Air Force base, career orientation, and other supplemental training.

Travel pay is provided for those attending the field training courses. During their stay, Air Force ROTC applicants in the six-week course receive $460, and those in the four-week course receive $566. All cadets are provided room and board while attending field training.

Eligibility Requirements. To be eligible for the Air Force ROTC program, a student must be: (1) a citizen of the United States; (2) physically qualified for commission in the United States Air Force in accordance with existing Air Force regulations; (3) not under 14 years of age and, upon graduation, not more than 28 years of age; (4) planning to pursue work leading to at least a bachelor's degree; (5) willing to sign a formal agreement and enlist in the Air Force Reserve at the beginning of the third year or, upon initiation of a college scholarship obligating him to remain in the ROTC program, to accept a commission and to serve the required period in the Air Force upon graduation.

21. Freshman Aerospace Studies (1) fall
A study of the doctrine, mission, and organization of the U.S. Air Force; a study of U.S. strategic offensive and defensive forces, their mission, function, and employment of nuclear weapons; and a study of civil defense. Capt. Fergus.

22. Freshman Aerospace Studies (1) spring
A study of aerospace defense; missile defense; U.S. general purpose and aerospace support forces; the mission resources and operations of tactical air forces with special attention to limited war; and a review of Army, Navy, and Marine general-purpose forces. Capt. Fergus.

23. Sophomore Aerospace Studies (1) fall
An examination of the developmental growth of air power over the past sixty years by reviewing the various concepts of employment and focusing upon the factors which prompted research and technological change. Col. Hasbrouck.

24. Sophomore Aerospace Studies (1) spring
A continuation of A.S. 23 with emphasis on a variety of events and elements in the history of air power, especially where these provide significant examples of the impact of the power on strategic thought. Col Hasbrouck.

111. Air Force Officer Development (3) fall
Development of the knowledge and skills required of the junior officer of the Air Force. This includes communicative skills, the development of air power, aerospace power today, and the future of manned aircraft. Capt. Fratto.

112. Air Force Officer Development (3) spring
Continuation of the development of knowledge and skills required of a junior Air Force officer with emphasis on the history and importance of the national space effort, orbits and trajectories, space vehicle systems, ground support systems, manned space flight, and operations in space. Capt. Fratto.

113. The Professional Officer (3) fall
Concepts of Air Force leadership. A study of the meaning of professional responsibilities of the professional officer, the foundations of the military profession, the military justice system, theories of leadership, discipline and human relations. Capt. Ziccardi.

114. The Professional Officer (3) spring
Concepts of Air Force management. Includes principles and functions of management, Air Force personnel policies, channels of communication, problem-solving, quantitative models and simulation, the command-staff team, the subordinate, performance standards, data processing, and Air Force controls. Capt. Ziccardi.

Corps Training
Each cadet participates a minimum of one hour per week during every semester of enrollment. Corps Training is scheduled at one time only, every Monday afternoon, for the entire cadet corps. The objective is to provide a laboratory environment wherein each student receives an opportunity to learn and develop leadership and management abilities. Cadets plan, organize, and carry out the entire Cadet Group program with only minimal guidance from the staff advisor. Cadets are promoted to cadet officer grades, in the corps, commensurate with their knowledge, experience, and demonstrated performance. Periodically, they move up the chain of command into positions of greater responsibility. Captain Fergus.

American Studies

American Studies Committee

William G. Shade, Ph.D., *Associate Professor of History and Director of American Studies*
Joseph Dowling, Ph.D., *Professor of History*
James R. Frakes, Ph.D., *Professor of English*
Lawrence Leder, Ph.D., *Professor of History*
E. Anthony James, Ph.D., *Associate Professor of English*
Edward J. Gallagher, Ph.D., *Associate Professor of English*

This is an interdepartmental major emphasizing the idea that

the institutions and values of a society comprise a whole and not merely a sum of separate parts. By concentrating on the unique expressions of individuals contained in the literature of America and by studying the historical movements within which these expressions develop, American Studies reveals relationships which may not be clearly seen within the framework of a single discipline. By carefully chosen electives the student can add to the insights of literature and history. Thus, for example, a student may pursue the relationship of the behavioral sciences to history and literature or use the various disciplines to give greater comprehension of the problems of the American city. In addition, the study in depth of one's own environment provides students with a greater awareness of the forces which have shaped their world and their character and should produce a greater sensitivity to the values of their own society.

The major consists of sequences in American history and literature, followed by twelve hours of advanced study divided equally between American history and American literature, six hours of electives in any aspect of the American experience and six hours of either European literature or European history. In the senior year, the student takes one history and one literature seminar organized around a single theme in each respective field. The major requirements total 42 hours.

Because the emphasis is strongly placed on American history and literature, an undergraduate American Studies major will provide thorough preparation for graduate work in American Studies and, with suitable collateral courses, American literature or American history. In addition, the major may help in preparing students for advanced work in law, theology, and teaching in secondary schools and community colleges.

Required Preliminary Courses

Hist 13, 14	American Civilization (6)
Engl 23, 24	American Literature (6)

Required Major Courses

Six credit hours to be chosen from each group.

Engl 321	20th Century American Literature (3)
Engl 341	Contemporary American Literature (3)
Engl 343	American Romanticism (3)
Engl 344	American Realism (3)
Hist 119	Colonial America (3)
Hist 120	Revolutionary America (3)
Hist 327	American Intellectual History (3)
Hist 328	American Intellectual History (3)

Six credit hours in European History or Literature.

Options

Electives in an American field (6)

Choice of electives and options to be made in consultation with advisor, selected from such disciplines as economics, fine arts, government, philosophy, religion, social relations.

Required Senior Seminars

Engl 345	Themes in American Literature (3)
Hist 374	Themes in American History (3)

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. Those interested in honors work are urged to consult the director.

Arts-Engineering

The standard major for arts-engineers working towards a B.A. degree is applied science. This includes all of the science and engineering courses required in the freshman year and included in the pattern roster for the chosen field of engineering.

Arts-engineers with special interests outside engineering frequently combine another arts or science major with their engineering program. Interested students should consult with the Dean of the College of Arts and Science.

Recommended Freshman Year

Arts-engineering freshmen have the same roster of courses as do engineering freshmen, with the exception that the arts-engineering freshman takes Economics 1 the second semester in place of an elective. Refer to the recommended freshman year, College of Engineering and Physical Sciences.

Recommended Professional Sequences

Beginning with the sophomore year, the arts-engineering student will be guided by the appropriate pattern roster in the chosen field. The pattern roster shows the most effective way of combining arts and engineering courses to prepare for the last year in the branch of engineering chosen.

Although the minimum number of credit hours needed for the Bachelor of Arts is 120, a student in arts-engineering should expect to earn more than this in order to qualify for the Bachelor of Science degree in his chosen field of engineering at the end of the fifth year. The number needed for both degrees is shown for each pattern roster.

Arts-Chemical Engineering

157 credit hours needed for B.A. and B.S.

Sophomore Year, First Semester (16 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
ChE 31	Equilibria (3)
ChE 41	Cascade Processing Concepts (3)
	Distribution Electives (6)

Sophomore Year, Second Semester (15 credit hours)

Math 205	Linear Methods (3)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
ChE 52	Introduction to Transport Phenomena (4)
	Distribution Elective (3)

Junior Year, First Semester (16 credit hours)

Chem 51	Organic Chemistry (3)
Chem 53	Organic Chemistry Lab (1)
Chem 187	Thermodynamics (3)
ChE 167	Unit Operations (3)
	Distribution Elective (6)

Junior Year, Second Semester (14 credit hours)

Chem 191	Physical Chemistry (3)
Chem 192	Physical Chemistry Lab (2)
ChE 286	Modeling, Simulation and Control (3)
	Distribution Elective (3)
	Elective (3)

Senior Year, First Semester (15 credit hours)

	Electives for Engineering Major (6)
	Distribution Electives (6)
	Elective (3)

Senior Year, Second Semester (14 credit hours)

ChE 169	Unit Operations Lab (1)
ChE 210	Chemical Engineering Thermodynamics (4)
	Elective for Engineering Major (3)
	Distribution Electives (6)

Summer

ChE 100	Industrial Employment

Note: For senior year engineering electives, the student should consult with department of chemical engineering advisors.

Arts-Civil Engineering

161 credit hours needed for B.A. and B.S.

Sophomore Year, First Semester (15 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
	Distribution Electives (6)

Sophomore Year, Second Semester (15 credit hours)

Math	Approved Mathematics Elective (3)
Mech 1	Statics (3)
	Distribution Electives (6)
	Elective (3)*

Junior Year, First Semester (15 credit hours)

Mech 11	Mechanics of Materials (3)
CE 13	Civil Engineering Concepts (3)
	Distribution Electives (9)

Junior Year, Second Semester (15 credit hours)

Mech 102	Dynamics (3)
CE 40	Principles of Surveying (3)
	Distribution Electives (9)

Summer (3 credit hours)

CE 41	Engineering Surveys (3)

Senior Year, First Semester (16 credit hours)

CE 101	Computer Methods (1)
CE 121	Mechanics of Fluids (3)
CE 143	Soil Mechanics (3)
CE 159	Structural Analysis (3)
	Electives (6)*

Senior Year, Second Semester (15 credit hours)

CE 110	Civil Engineering Laboratory (3)
CE 160	Structural Design (3)
CE 170	Environmental Engineering (3)
CE 222	Hydraulic Engineering (3)
	Elective (3)*

Summer

CE 100	Summer Employment Eight weeks of summer employment should precede fifth year. Consult chairman of department.

*Electives which require approval of civil engineering department.

Arts-Electrical Engineering

157 credit hours needed for B.A. and B.S.

Sophomore Year, First Semester (15 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
	Distribution Elective (6)

Sophomore Year, Second Semester (16 credit hours)

Math 205	Linear Methods (3)
Mech 103	Principles of Mechanics (4)

Distribution Elective (3)
Electives (6)

Junior Year, First Semester (15 credit hours)

EE 11 Introduction to Computer Engineering (3)
Math 231 Statistical Inference or
Math 309 Theory of Prabability (3)
Distribution Electives (9)

Junior Year, Second Semester (16 credit hours)

EE 20 Introduction to Circuit Theory (4)
Phys 31 Introduction to Quantum Mechanics (3)
Distribution Electives (9)

Senior Year, First Semester (14 credit hours)

EE 105 Electronic Circuits (4)
EE 104 Linear Systems and Signals (4)
Approved Electives (3)
Distribution Elective (3)

Senior Year, Second Semester (14 credit hours)

EE 103 Physical Electronics (3)
EE 231 Electric and Magnetic Fields (3)
EE 106 Electromechanics and Machines (3)
EE 142 Junior Lab (2)
Approved Electives (3)

Summer

EE 100 Industrial Employment

Note: students must choose at least one elective in mathematics and at least one elective in materials, thermodynamics, fluid mechanics, or physical chemistry.

Arts-Engineering Physics

158 credit hours needed for B.A. and B.S.

Arts-engineering physics students will complete, during the first four years, the physics major under the guidance of the chairman of the department of physics.

Arts-Industrial Engineering

159 credit hours needed for B.A. and B.S.

Sophomore Year, First Semester (15 credit hours)

Math 23 Analytic Geometry and Calculus III (4)
Phys 21 Introductory Physics II (4)
Phys 22 Introductory Physics Lab II (1)
IE 5 Industrial Organization Models (3)
Distribution Elective (3)

Sophomore Year, Second Semester (15 credit hours)

IE 110 Engineering Probability (3)
IE 18 Data Processing Fundamentals (3)
Engineering Science Elective (3)
Distribution Electives (6)

Junior Year, First Semester (15 credit hours)

Math 205 Linear Methods (3)
IE 205 Engineering Statistics (3)
Engineering Science Elective (3)
Distribution Electives (6)

Junior Year, Second Semester (16 credit hours)

IE 206 Operation Research Techniques (4)
Engineering Science Elective (3)
Distribution Electives (6)
Elective (3)

Senior Year, First Semester (16 credit hours)

IE 101 Fundamentals of Manufacturing Engineering (4)
Engineering Science Elective (3)
Distribution Electives (9)

Senior Year, Second Semester (15 credit hours)

IE 102 Work Systems (3)
Engineering Science Electives (6)
Electives (6)

Summer

IE 100 Industrial employment should precede fifth year. Consult chairman of department.

Note: Engineering science electives must be cleared with the department of industrial engineering.

Arts-Mechanical Engineering and Engineering Mechanics

158 credit hours needed for B.A. and B.S.

Sophomore Year, First Semester (17 credit hours)

Phys 21 Introductory Physics II (4)
Phys 22 Introductory Physics Lab II (1)
Math 23 Analytic Geometry and Calculus III (4)
ME 12 Engineering Drawing and Descriptive Geometry (2)
Distribution Elective (6)

Sophomore Year, Second Semester (15 credit hours)

Mech 1 Statics (3)
Math 205 Linear Methods (3)
ME 104 Thermodynamics I (3)
Distribution Elective (3)
Elective (3)

Junior Year, First Semester (16 credit hours)

Met 63 Engineering Materials and Processes or
Met 91 Elements of Materials Science (3)

ME 101	Mechanical Engineering Design (1)
Mech 11	Mechanics of Materials (3)
	Distribution Electives (9)

Junior Year, Second Semester (14 credit hours)

Mech 102	Dynamics (3)
Mech 13	Materials Testing Laboratory (1)
ME 231	Fluid Mechanics (3)
EE 160	Electrical Circuits and Apparatus (4)
EE 162	Dynamo Laboratory (1)
ME 102	Mechanical Engineering Design II (2)

Senior Year, First Semester (15 credit hours)

ME 105	Thermodynamics II or
	Approved Elective (3)
Math 208	Complex Variables or
Math 231	Statistical Inference (3)
	Distribution Electives (6)
	Elective (3)

Senior Year, Second Semester (16 credit hours)

Mech 203	Advanced Strength of Materials (3)
CE 123	Fluid Mechanics Laboratory (1)
ME 242	Mechanical Vibrations (3)
	Distribution Electives (6)
	Elective (3)

Summer

ME 100	Summer employment should precede fifth year. Consult department chairman.

Arts-Metallurgy and Materials Science

159-161 credit hours needed for the B.A. and B.S., depending on option selected

Sophomore Year, First Semester (15 credit hours)

Met 63	Engineering Materials and Processes or
Met 91	Elements of Materials Science (3)
Math 23	Analytic Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
	Distribution Elective (3)

Sophomore Year, Second Semester (16-17 credit hours)

Met 10	Metallurgy Laboratory (1)
Mech 1	Statics (3)
EE 160	Electrical Circuits and Apparatus or
Phys 31	Introduction to Quantum Mechanics (3-4)
	Distribution Elective (6)
	Elective (3)

Junior Year, First Semester (15 credit hours)

Met 207	Electron and Crystal Structure (3)
Met 210	Metallurgical Thermodynamics (3)
Mech 11	Mechanics of Materials (3)
ChE 60	Engineering in Chemical Manufacturing (3)
	Distribution Elective (3)

Junior Year, Second Semester (15 credit hours)

Met 208	Phase Diagram and Transformations (3)
Met 218	Mechanical Behavior of Materials (3)
	Distribution Electives (9)

Senior Year, First Semester (15 credit hours)

Met 307	Structure and Behavior of Materials (3)
Math 205	Linear Methods or
Math 231	Statistical Inference (3)
	Distribution Electives (6)
	Electives (3)

Senior Year, Second Semester (16-17 credit hours)

ME 166	Procedures for Mechanical Design or
Mech 102	Dynamics (2-3)
Met 304	Extractive Metallurgy I (4)
Met 101	Professional Development (1)
	Distribution Electives (6)
	Electives (3)

Summer

Met 100	Industrial employment should precede fifth year. Consult chairman of department.

Note: students interested in the Industrial or Research option should consult with the department chairman prior to their fourth year. Students selecting the Research option should elect Met 240, Research Techniques, in the second semester of the senior year.

Biology

Professors

Saul B. Barber, Ph.D., *Chairman*
Sidney S. Herman, Ph.D., *Director, The Wetlands Institute*
Richard G. Malsberger, Ph.D.

Associate Professors

Hayden N. Pritchard, Ph.D.

Assistant Professors

Barry Bean, Ph.D.
David Bell, Ph.D.

Patricia Bradt, Ph.D.
Donald Hosier, Ph.D.
Steven S. Krawiec, Ph.D.

Adjunct Professors

Edward J. Benz, M.D.
Eugene M. Landis, M.D., Ph.D.
Lionel Walford, Ph.D.
Carl J. Sinderman, Ph.D.

The biology department offers students a choice of two majors, the Bachelor of Arts in biology and the Bachelor of Science in biology. The principal differences in requirements for the two majors are:

1. The B.A. course of study requires the student to complete the distribution requirements of the College of Arts and Science in addition to the requirements of the biology major.

2. The B.S. course of study requires that, in addition to the requirements of the biology major, the student complete a total of 33 hours with the only elective restriction being that they be outside the fields of natural science and mathematics.

3. The B.A. curriculum has a total of 53 hours of courses in the major requirements as compared to 82 in the B.S. curriculum.

The B.A. major in biology is not designed specifically for pre-professional training but it does exceed the minimum requirements for admission to medical, dental and allied professional colleges as well as to study for advanced degrees in most of the fields of graduate biology. It is, therefore, recommended to those students who desire an adequate background in biology combined with the cultural background of the arts college distribution requirements.

The B.S. major in biology is designed specifically for optimal scientific preparation for entry into professional graduate training in medicine, dentistry and allied professional fields as well as in graduate biology. Such pre-professional training is obtained at the cost of a reduction in the number of non-science courses a student will be able to take during a normal four-year undergraduate program. Students should, therefore, consider carefully before committing themselves to either program. An initial choice of one or the other program is revisable, although this becomes more difficult after the freshman year.

Students may also apply for acceptance in one of the two six-year B.A.-M.D. programs offered in cooperation with two Philadelphia medical schools. The Lehigh University B.A. requirements with a major in biology are completed and the M.D. requirements of one of the cooperating medical schools are also completed, both within a six-year period. For details of both programs students should consult the course listing on Health Professions.

The Bachelor of Arts Major

Required Courses in Biology

Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Laboratory (1)
Biol 28	Genetics (3)

Plus nine hours of organismic biology including one course in botany, six hours of environmental biology, and six hours of cellular biology.

Organismic Biology

Biol 34	Comparative Anatomy (4)
Biol 303	Invertebrate Zoology (3)
Biol 313	General Histology (3)
Biol 314	Vertebrate Embryology (3)
Biol 331	Non-vascular Plants (3)
Biol 332	Vascular Plants (3)

Environmental Biology (3)

Biol 306	Ecology (3)
Biol 309	Aquatic Biology (3)
Biol 333	Symbiosis (3)
Biol 324	Animal Behavior (3)
Biol 317	Evolution (3)
Biol 361	Sanitary Microbiology (3)

Cellular Biology

Biol 35	Microbiology (3)
Biol 320	Cell Physiology (3)
Biol 353	Virology (3)
Biol 333	Symbiosis (3)
Biol 371, 372	Biochemistry (3)
Biol 322	Animal Physiology (3)

Additional Required Courses

Math 41	BMSS Calculus (3)
Math 42	BMSS Probability (3)
Math 43	BMSS Linear Algebra (3)
Chem 21, 22	Chemical Principles & Laboratory (5)
Chem 51, 52, 55	Organic Chemistry & Laboratory (8)
Chem 39	Analytical Chemistry or
Chem 31	Chemical Equilibria in Aqueous Systems or
Chem 194	Physical Chemistry (3)
Phys 11, 12	Introductory Physics and Laboratory (5)
Phys 13, 14	General Physics and Physics Laboratory (4)

Recommended Sequence of Science Courses

Freshman Year

Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Laboratory (1)
Biol 28	Genetics (3)
Chem 21	Chemical Principles I (4)
Chem 22	Chemical Principles I Laboratory (1)
Math 41	BMSS Calculus (3)
Math 42	BMSS Probability (3)
Phys 11, 12	Introductory Physics I (5)

Sophomore Year

Chem 51, 52	Organic Chemistry (6)
Chem 55	Organic Chemistry Laboratory (2)

Phys 13, 14	General Physics (4)
Math 43	BMSS Linear Algebra (3)
Biol	Electives (3 or 6)

Junior Year

Chem 39	Analytical Chemistry or
Chem 31	Chemical Equilibria or
Chem 194	Physical Chemistry (3)
Biol	Electives (3, 6, or 9)

Senior Year

Biol	Electives (3, 6, or 9)

The Bachelor of Science Major

Required Courses in Biology

Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Lab (1)
Biol 28	Genetics (3)

Plus nine hours from each of the following areas including at least one course in botany.

Organismic Biology

Biol 34	Comparative Anatomy (4)
Biol 303	Invertebrate Zoology (3)
Biol 313	General Histology (3)
Biol 314	Vertebrate Embryology (3)
Biol 331	Non-vascular Plants
Biol 332	Vascular Plants (3)

Environmental Biology

Biol 306	Ecology (3)
Biol 309	Aquatic Biology (3)
Biol 333	Symbiosis (3)
Biol 324	Animal Behavior (3)
Biol 317	Evolution (3)
Biol 361	Sanitary Microbiology (3)

Cellular Biology

Biol 35	Microbiology (3)
Biol 320	Cell Physiology (3)
Biol 353	Virology (3)
Biol 333	Symbiosis (3)
Biol 371, 372	Biochemistry (6)
Biol 322	Animal Physiology

Additional Required Courses

Math 21, 22, 23	Analytic Geometry and Calculus (12) or
Math 41, 42, 43, 44	BMSS Calculus, Probability and Linear Algebra (12)
Chem 21	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Lab (1)
Chem 51, 52	Organic Chemistry (6)
Chem 55	Organic Chemistry Lab (2)
Chem 31	Chemical Equilibria (3)
Chem 187 or 194	Physical Chemistry (3)
Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Lab I (1)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
Geol 1	Principles of Geology (3)
	and one of the following:
Psych 3	Psychology as a Natural Science (3)
Psych 9	Statistical Analysis (3)
Phil 261	Philosophy of the Natural Sciences (3)

and 33 hours of non-science electives.

Recommended Sequence of Science Courses

Freshman Year

Biol 21, 22	Principles of Biology and Lab (4)
Biol 28	Genetics (3)
Math 21, 22	Analytical Geometry and Calculus I, II (8) or
Math 41, 42	BMSS Calculus and Probability (6)
Chem 21, 22	Chemical Principles I and Lab (5)
Phys 11, 12	Introductory Physics I and Lab (5)

Sophomore Year

Chem 51, 52, 55	Organic Chemistry and Lab (8)
Math 23	Analytic Geometry and Calculus III (4) or
Math 43, 44	Calculus and Linear Algebra (6)
Phys 21, 22	Introductory Physics II and Lab (5)
Chem 31	Chemical Equilibria
Biol	Electives (6)
Psych	Elective or
Phil	Elective (3)

Junior Year

Chem 187 or 194	Physical Chemistry (4)
Geol 1	Principles of Geology (3)
Psych	Elective or
Phil	Elective (3)
Biol	Electives (6-12)

Senior Year

Biol	Electives (6-12)

The Biology Minor

A minor in biology may be achieved by completing the following requirements:

Biol 21, 22	Principles of Biology and Lab (4)
Biol	Electives (12)
Chem 21, 22	Chemical Principles and Lab (5)
Chem 51	Organic Chemistry (3)
Phys 11, 12	Introductory Physics and Lab (5)
Math 41	BMSS Calculus (3)
	Total Credits 32

Undergraduate Courses

21. Principles of Biology (3) fall-spring
Introduction to biology by study of selected principles. Topics covered include cell structure and function, plant and animal structure and function, diversity and evolution of organisms. Three lectures per week.

22. Introduction to Biology Laboratory (1) fall-spring
Laboratory observations and experiments to illustrate how biological information is acquired. Designed primarily as a laboratory to accompany Biology 21. Prerequisite: Biology 21 previously or concurrently. One three-hour laboratory per week. Graded only pass-fail.

28. Genetics (3) fall-spring
The basic laws governing inheritance in plants and animals, chromosome behavior, nature of genes. The relation of environmental modifications, hybrid variation, and mutations to the mechanics of evolution. Messrs. Bean or Malsberger.

34. Comparative Vertebrate Anatomy (4) fall
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 each week. Prerequisite: Biol. 21 and 22, or equivalent; sophomore standing. Mr. Owen.

35. Microbiology (3) fall-spring
Emphasis on the appearance, physiology, and taxonomy of prokaryotes. Selected subjects pertaining to relations between man and microorganisms. Prerequisite: a laboratory course in biology. Mr. Krawiec.

For Advanced Undergraduates and Graduates

221. Undergraduate Research (3)
Laboratory work, field work, or both depending upon the interest and competence of the student. Prerequisites: junior standing and consent of department chairman.

231. Natural History and Ecology (3) summer session
A concentrated course in recognition of species of plants and animals and study of their interrelationships in natural and altered environments. Lectures and seminars in use of keys and preservation of collections. Designed for secondary school teachers in life sciences. Prerequisites: graduate standing or consent of department chairman. Mr. Trembley.

232. Natural History and Ecology Workshop (3)
Field and laboratory work in natural history and ecology. Must be taken concurrently with Biol. 231.

241. Ecology of Wetlands (6) summer
Study of plants and animals of wetlands areas and their interrelationship with the environment. The importance of the wetlands to the marine environment and methods of conservation. Independent study will form part of the course. Primarily designed for secondary school teachers of the sciences. Prerequisite: consent of chairman. (Offered only at The Wetlands Institute.)

261. Special Topics in 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 department chairman.

262. Special Topics in Biology (1-3)
Continuation of Biology 261.

303. Invertebrate Zoology (3) spring
Detailed survey of representative invertebrates. Anatomical and histological examination of selected types. Concepts of evolution and speciation. Two lectures, one laboratory per week. Prerequisite: two semesters of biology, one with laboratory. Mr. Herman.

306. Ecology (3) fall-spring
Basic principles of ecological interrelationships from a systems analysis perspective. Examination of ecological phenomena at the individual, population, community, and ecosystem levels. Two lectures and one laboratory period or field trip per week. Prerequisite: two semesters of biology, one with laboratory. Messrs. Bell or Herman.

309. Aquatic Biology (3) alternate years
Lectures on the physical, chemical and biological aspects of the fresh water environment including cyclic and seasonal changes. A consideration of the major groups of organisms and their interactions. Influence of man-made alterations including impoundments and waste disposal methods. Two lectures and one laboratory period or field trip per week. Prerequisites: Biol. 21, 22 or equivalent. Mr. Bell.

313. General Histology (3) spring
The techniques of preservation and preparation of animal and plant tissues for microscopical study; comparative studies of fresh and preserved tissues. One lecture and two laboratory periods per week. Prerequisite: Biol. 21 and 22 or equivalent, Biol. 34 or equivalent recommended. Mr. Owen.

314. Vertebrate Embryology (3) spring
A study of reproduction from germ cell formation through establishment of the principal organ systems of the vertebrate body. Various mechanical and physiological problems confronting the growing embryo are considered, and direct observation of whole mounts, sections, and living material are made in the laboratory. Two lectures and one laboratory period each week. Prerequisite: Biol. 34 or equivalent. Mr. Owen.

317. (Geol. 317) Evolution (3) fall
The origin of species and higher categories with emphasis on animals. Isolating mechanisms, population structure, rates of evolution, extinction. Prerequisite: two semesters of biology or consent of instructor. Mr. Barber.

320. Cell Physiology (3) fall
The fundamental processes of life at the cellular level, including permeability and related membrane phenomena, enzymatic transformations, respiration, photosynthesis, gene function, bioelectricity, and other aspects of neuron function, contractility and other kinds of protoplasmic motility. Prerequisites: two semesters of biology, at least one with laboratory, Chem. 52, or consent of department chairman. Messrs. Barber, Hosier or Krawiec.

322. Animal Physiology (3) spring
The physiology of organs and organ systems in animals. Emphasis on mammalian systems, but lower vertebrates and invertebrates are also included. Functions studied include digestion, nutrition, metabolism, excretion, respiration, circulation, locomotion, nervous and chemical coordination. Prerequisites: two semesters of biology, at least one with laboratory, Chem. 52 or consent of department chairman. Mr. Barber.

324. Animal Behavior (3) spring
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 specific behavior patterns. Prerequisite: Biol. 21 or consent of department chairman. Mr. Bell.

325. Advanced Genetics (3) fall
Lectures and student contributions on selected aspects of genetics, with emphasis on the molecular approach. The structure, organization, and replication of genes. The expression of genetic information and its regulation in cellular and developmental biology. Prerequisite: Biol. 28 or consent of department chairman. Mr. Bean.

327. Regulatory Biology (3)
Survey of biological regulatory systems and their mechanisms of operation at the biochemical, subcellular, cellular, and organismic levels. Particular attention to the means by which organisms deal with their continuously changing environment (i.e., behavior, adaptation, evolution). Two lectures, one laboratory. Prerequisites: Biol. 21, 28. Mr. Bean.

331. Non-vascular Plants (3) fall
A comparative study of the ontogenetic and phylogenetic development of algae, fungi and bryophytes. The life cycles and ecological importance of representative organisms are examined. Two lectures and one laboratory. Prerequisite: Biol. 21. Ms. Bradt or Mr. Pritchard.

332. Evolution of Vascular Plants (3) spring
A comparative study of the ontogenetic and phylogenetic development of vascular plants. The life cycles, ecological importance and cellular morphology of the higher plants are examined. Emphasis on the plants of Pennsylvania. Prerequisite: Biol. 21. Ms. Bradt or Mr. Pritchard.

333. Symbiosis (3) fall
Consideration of factors governing symbiotic relationships, including phoresis, commensalism, parasitism, and mutualism. Lectures and demonstrations emphasizing the theoretical and applied aspects of morphological and physiological adaptation, nutrient assimilation and metabolism, development, host reactions, and the dynamics of host-symbiont interactions are presented. Laboratory experiments designed to acquaint the student with techniques, evaluation of data, and to demonstrate principles are carried out. Prerequisite: Biol. 21. Two lectures and one laboratory period per week. Mr. Cheng.

341. Biology of Marine Animals (6) summer
Emphasis on comparative morphology and physiology of marine animals. Field trips for ecological observation and collection as well as anatomical study and physiological experimentation. Prerequisite: consent of instructor and two semesters of biology. (Offered only at The Wetlands Institute.) Messrs. Barber and Bell.

353. Virology (3) spring
A lecture course on bacterial and animal viruses including taxonomy, physical and chemical properties, and the biochemical transformations of infected cells. Prerequisite: a course in microbiology or biochemistry. Mr. Malsberger.

361. Sanitary Microbiology (3) spring
Laboratory, field work, and reports on the microbiology of water supplies, waste disposal, and food processing. Prerequisite: one semester each of microbiology and analytical chemistry. Mr. Malsberger.

371. (Chem. 371) Elements of Biochemistry (3)
For course description, see Chem. 371.

372. (Chem. 372) Advanced Biochemistry (3)
For course description, see Chem. 372.

Mini Courses at the Wetlands Institute

The following courses, Biology 381 through 386, are one-credit mini courses offered only at The Wetlands Institute. Approval of the department chairman is required for all of the courses.

381. Phytoplankton of Estuaries (1)
Survey of the phytoplankton found in New Jersey salt marsh waters. Laboratory work in collecting and identifying organisms, and lectures on the morphology, biochemistry, and physiology of the organisms.

382. Plant Succession in Salt Marshes (1)
Survey of the large plants found in salt marshes and in other marine environments. Field work collecting and identifying the plants; lectures on their biochemistry, physiology, and morphology.

383. Marine Invertebrate Zoology (1)
The dominant taxa of the marine environment: the wetlands fauna, including taxonomy, life history, adaptations, and interrelationships of these organisms. Consideration of the environmental parameters determining the distribution and

abundance of marine fauna. Utilization of live specimens and the Wetlands collections to provide a high degree of instructional display.

384. Estuarine Zooplankton (1)
Study of temporary and permanent members of the animal plankton of shallow water. Sampling techniques, life histories, and morphology of major forms. Lectures, laboratories, and field trips.

385. Marine Habitats (1)
Ecological field course in the planktonic, benthic, marsh, and sand beach habitat of the South Jersey coast. Emphasis on the major biotic associations in each area and their relationship to physical and chemical influences in the environment. Competition and predation in each habitat.

386. Marine Fish Taxonomy (1)
Lectures in anatomy and physiology of marine fishes. Laboratory will emphasize collecting procedures and identification of specimens.

For Graduates

The biology department accepts a limited number of students who are interested in graduate study towards the Ph.D. degree. Candidates for M.S. degrees are also accepted but emphasis is on the former degree. Currently the department averages about twenty full-time graduate students in residence each year.

The training program initially emphasizes breadth in biology followed by concentration in a special field of interest. Because of the small size of the department staff and the restricted number of graduate students, staff and students work together very closely, especially during the years of student specialization.

The first two or two and one-half years are devoted primarily to course work but some of these are special research and readings courses that may serve as starting points for thesis research. Staff members normally direct student research programs only in the areas encompassed by their own research interests. These are: comparative physiology of nerve and muscle, virology, biological oceanography, behavioral genetics, histochemistry, aquatic biology, biological aspects of water pollution, symbiosis and parasitism, and biology of nucleic acids. Interdisciplinary programs in biological aspects of marine sciences may also be arranged in cooperation with the Center for Marine and Environmental Studies.

Special department requirements for the M.S. degree include one year of graduate biochemistry, two semesters of graduate statistics and at least one semester of research, as well as passing an M.S. qualifying examination. Requirements for the Ph.D. degree are determined by the student's special committee and are tailored to fit special needs and interests, but also include passing a special examination as well as a defense of the Ph.D. thesis.

The prerequisite for graduate work in biology is undergraduate training in biology, chemistry, physics and mathematics approximately equivalent to that taken by biology majors at Lehigh University. Minor deficiencies in these areas may be completed during the first year of graduate study, usually, however, without graduate credit. Candidates for admission to graduate study in biology should take the Graduate Record (G.R.E.) Advanced Test in Biology as well as the G.R.E. Verbal and Mathematical Aptitude tests. Failure to include results of these examinations with application for admission can seriously delay or prevent action on the application.

Current departmental projects of special interest are as follows: neurophysiological mechanisms in animal behavior; viral diseases of fresh-water fishes; biological surveys of lakes; thermal and industrial pollution of the Delaware River; salt marsh ecology; periphyton and water quality; cytochemistry of lymphocystis tumor cells; behavioral genetics; physiology of parasites, physiological ecology of marine symbionts, invertebrate immunobiology, and nucleic acids of microorganisms.

An interdisciplinary Ph.D. program in molecular biology is offered by a committee of molecular biologists with members from the departments of biology, chemistry and physics. For details of the program consult the section on Interdisciplinary Graduate Programs.

Graduate Courses

402. Comparative Animal Physiology (3)
Lectures and seminars on selected areas in the comparative physiology of animals. Introduction to the current literature of subjects studied. These include mechanisms of osmotic control, temperature effects, nerve and muscle physiology and others. Prerequisite: Biol. 320 or 322. Mr. Barber.

405. Special Topics in 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. Biological Seminar (1)
An advanced seminar in current developments including departmental research. Required for candidates for graduate degrees. May be taken more than once for credit.

407. Biological Research (3)
Investigations in any phase of the biological sciences according to the student's preparation and interests.

408. Biological Research (3)
Continuation of Biol. 407.

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 interest of the student. Mr. Owen.

411. General Cytology (3)
Conferences, assigned readings, and laboratory work on the structural features of the cell in relation to cellular function

and on modern methods of preparing living and fixed tissues for cytological study. Included are special studies of the cytology of microorganisms. Prerequisite: Biol. 313. Mr. Owen.

412. Biological Membranes (3)
Membranes, structures essential to the organization of prokaryotes and eukaryotes, will be studied in terms of their appearances, distributions, compositions, molecular organizations, and functions. The problems of genetic determination and synthesis of membranes will also be approached. Emphasis will be placed on membrane models generated by results from current research. Readings, lectures, and recitations. Mr. Krawiec.

414. Advanced Ecology (3)
Seminars, conferences, and directed field work with emphasis on theoretical models and their application to real biological systems. Prerequisite: consent of department chairman. Messrs. Herman or Bell.

415. Cytochemistry (3)
A study of morphological and biochemical events during cell growth and differentiation including lectures, labs, and student reports on current literature. Special emphasis is placed on developmental patterns and laboratory procedures of the cytochemist. Prerequisite: consent of department chairman. Mr. Pritchard.

416. Immunology (3)
Consideration of antigen-antibody systems from theoretical and practical aspects. Lectures and reports on the structure and origins of antigens and antibodies and the mechanisms of agglutination, precipitation, complement fixation, anaphylaxis, etc. Laboratory work on preparation, standardization, and assay of antigens and antibodies. Prerequisite: Biol. 353, or Chem. 371. Mr. Malsberger.

417. Marine Ecology (3)
Advanced study of the physical and chemical influences in the marine environment on organisms and their interrelations. Ecological theory pertaining to population dynamics and energy flow. Three lecture periods per week. Prerequisite: consent of department chairman. Mr. Herman.

418. Biological Oceanography (3)
Surveys of marine plant and animal plankton, nekton and benthos. Composition of various groups, productivity, interrelationships of plants and animals and the role of microorganisms in the sea. Three lectures per week. Prerequisite: consent of department chairman. Mr. Herman.

420. Cellular Mechanisms (3)
Discussions focused on the molecular mechanisms underlying the biology of cellular and microbial systems. Specific topics emphasizing the interests of the participants, but might include: microbial behavior; the evolution and genetics of subcellular specialization; active transport; nucleic acid biochemistry; chromosome replication; cell surface specificities; the functioning of organelles; intracellular and intercellular coordination; viral specificity and reproduction. Mr. Bean.

421. Morphogenesis of the Lower Invertebrates (3)
The structural and chemical aspects of normal and teratological development among the acoelomate and pseudocoelomate phyla are considered from the standpoint of cell and tissue differentiation, comparative morphological and physiological functions, exogenous stimulatory factors, and metabolic requirements. Mr. Cheng.

423. The Biology of Transplantation (3)
The mechanisms, both cellular and humoral, responsible for the recognition of 'self' from 'nonself' in the animal kingdom and the reactive processes resulting from such are explored from the viewpoint of immunity, nutritional uptake, and ontogenetic factors. Mr. Cheng.

425. Biological Electron Microscopy (3)
Uses of the transmission and scanning electron microscopes in biology. Laboratory work in the preparation of biological specimens for study with both kinds of electron microscopes and some independent work at the transmission electron microscope. Study of current information on cell ultrastructure. Mr. Barber or Mr. Krawiec.

433. Growth and Development in Plants (3)
A comparative study of embryo and cellular development in the plant kingdom including the algae, bryophytes and tracheophytes. Emphasis is placed on morphology, physiology and the role of macromolecular substances during growth and differentiation. Literature search, experimental work and oral reports. Two lectures, one lab. Mr. Pritchard.

435. Ethology (3)
Advanced topics in behavior, including stereotyped action patterns, receptor and central nervous information processing, and techniques of behavioral investigation. Seminar format. Prerequisite: consent of department chairman. Mr. Bell.

441. Marine Botany (3)
A study of the morphological, physiological, biochemical and ecological features of those plants found primarily in the salt water environment. Emphasis will be placed on the evolutionary and ecological significance of the phytoplankton, benthic algae and rooted aquatic plant divisions associated in and near the oceans. The economic importance of these plants will be considered. Laboratory work, field work and library searches and reports. Messrs. Pritchard and Herman.

442. Marine Zooplankton (3)
A comprehensive study of neritic and oceanic plankton. Studies on the life history, morphology and distribution of both holoplanktonic and meroplanktonic animals. Prerequisite: consent of department chairman. Mr. Herman.

443. Ichthyology (3)
Lectures and laboratory on the anatomy, physiology, behavior and taxonomy of marine and freshwater fishes. Mr. Malsberger.

445. Nucleic Acids and Nucleic Acid Compiexes (3)
Structure of DNA, replicative intermediates and chromosomes; messenger RNA, transfer RNA, ribosomal RNA, and ribosomes. Readings, lectures, and recitations. Prerequisite: consent of department chairman. Mr. Krawiec.

447. (Chem. 447) Experimental Molecular Biology (3)
A survey of current research in molecular biology.

480. (Geol 480) Marine Science Seminar (1)
An advanced interdisciplinary seminar on various problems of marine sciences, with visiting speakers and student presentations. May be substituted for Biol. 406.

Chemical Engineering

Professors

Leonard Andrew Wenzel, Ph.D., *Chairman*
Alan Shivers Foust, Ph. D., *McCann Professor*
Curtis William Clump, Ph.D.
Robert William Coughlin, Ph.D.
William L. Luyben, Ph.D.
William Edward Schiesser, Ph.D.
Fred P. Stein, Ph.D.

Associate Professors

Gary Wayne Poehlein, Ph.D.
Leslie H. Sperling, Ph.D.

Assistant Professors

Marvin Charles, Ph.D.
Mohammud El Aasser, Ph.D.
Anthony J. McHugh, Ph.D.

Lecturers

Jacob Myer Geist, Ph.D.
Abraham Lapin, Ph.D.
Clyde McKinley, Ph.D.

Research Associates

Pavel Ditl, Ph.D.
Joseph V. Hoffman, Ph.D.

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, and national defense programs.

Preparation for this broad field requires a sound background in the fundamental sciences of physics, chemistry, and mathematics plus a general background training in the application of these fundamentals to carrying forward into industrial production the new products and processes discovered in the laboratory. This latter training is directly called chemical engineering. In accord with this philosophy, the student is not trained for any specific industry, but the education is sufficiently broad that a graduate is competent to enter any of the chemical and allied industries.

The aim of the curriculum is to develop in the student understanding of the scientific fundamentals, an ability with mathematical tools, and the habits of precise analysis of process engineering problems that will allow him or her to function effectively in this broad field, and to grow into positions of responsibility. Of course these technical abilities must be coupled with an understanding of the economic, sociological, and cultural environment within which the engineer operates. The curriculum includes a relatively large commitment to education in these latter areas.

The program is also designed to prepare a student for graduate study in chemical engineering or in peripheral fields. Further study at the graduate level leading to advanced degrees is highly desirable in preparation for careers in the more highly technical aspects of manufacturing. The increasing complexity of modern manufacturing methods requires superior training for men and women working in the research, development, and design fields or for teaching.

Recommended Sequence of Courses

Freshman Year: see Recommended Freshman Year, page 52

Sophomore Year, First Semester (17 credit hours)

Math 23	Analytical Geometry and Calculus III (4)
ChE 41	Cascade Processing Concepts (3)
Chem 31	Equilibria (3)
Eco 1	Economics (4)
	Elective (3)

Sophomore Year, Second Semester (15-18 credit hours)

Math 205	Linear Methods (3)
ChE 52	Introduction to Transport Phenomena (4)
Phys 21, 22	Introductory Physics II & Lab (5)
	Electives (3-6)*

Junior Year, First Semester (16 credit hours)

Chem 187	Thermodynamics
Chem 51, 53	Organic Chemistry & Lab (4)

ChE 167	Unit Operations (3)
	GS Requirement (3)
	Elective (3)

Junior Year, Second Semester (17 credit hours)

Chem 191	Physical Chemistry (3)
ChE 286	Modeling, Simulation, and Control (3)
ChE 210	Thermodynamics (4)
ChE 169	Unit Operations Lab I (1)
	GS Requirement (3)
	Electives (3)

Summer

ChE 100	Industrial Employment

Senior Year, First Semester (15-18 credit hours)

ChE 174	Chem Plant Design (3)
ChE 302	Chemical Engineering Kinetics (3)
ChE 170	Unit Operations Lab II (1)
Chem 192	Physical Chem. Lab (2)
	GS Requirement (3)
	Electives (3-6)*

Senior Year, Second Semester (15-18 credit hours)

	GS Requirement (3)
	Electives (12-15)*

The twenty-seven hours of electives included in the minimum degree program must be taken from the following distribution:

Chemistry: six hours
Engineering sciences: (including Mech 1 or Mech 103): twelve hours
Free electives: nine hours

*Please refer to description of normal program, page 52.

Undergraduate Courses

41. Cascade Processing Concepts (3) fall
Concepts of equilibrium in gas, liquid, and solid systems. Engineering of sequential and cascade processing methods from technical and economic considerations. Computer modeling of leaching, extraction, and distillation processes. Prerequisite: Engr. 1 or equivalent in programming.

52. Introduction to Transport Phenomena (4) spring
The principles of transport of energy, momentum, and mass and the analogies between them. Transport coefficients and their evaluation. Applications in variable-property fields within a phase. Three recitations and one lab per week.

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.

100. Summer Employment
During the summer (preferably following the junior year) candidates for the degree of B.S. in chemical engineering are required to obtain industrial experience through employment for at least eight weeks in a plant or laboratory or engineering office and submit a report thereon.

167. Unit Operations (3) fall
Applications of transport phenomena and conservation principles as applied to chemical processing equipment. Prerequisite: Ch.E. 52.

169. Unit Operations Laboratory I (1)
Laboratory experience in unit operations. Prerequisite: Ch.E. 167 previously or concurrently.

170. Unit Operations Laboratory II (1)
Laboratory experience with steady state and dynamic process operations. Prerequisite: Ch.E. 286 previously or concurrently.

174. Chemical Plant Design (3) fall
A study of the technical and economic aspects of the design, location, and operation of chemical plants. Prerequisite: Ch.E. 166 or Ch.E. 286.

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.

186. Undergraduate Research II (3)
A continuation of the project begun under Ch.E. 185. Prerequisites: Ch.E. 185 and consent of the department chairman.

For Advanced Undergraduates and Graduates

210. Chemical Engineering Thermodynamics (4) spring
Energy relations and their application to chemical engineering. Consideration of flow and non-flow 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: Chem. 187 or equivalent.

286. Modeling, Simulation, and Control (3) spring
Review of physical laws that are the basis for mathematical models of physical systems. Mathematical modeling of important chemical engineering systems. Digital and analog computer simulation techniques for solution of ordinary differential equations describing chemical processes. Practical aspects of process control system design and operation. Exposure to control equipment: sensors, transmitters, controllers and control valves. Prerequisite: Math 205.

300. Apprentice Teaching in Ch.E. (1-3)

301. Process Design (3) spring
Study of the strategy of chemical process design with empha-

sis on optimum order of steps, flow diagrams, energy balances, recycle ratios and their effect on the economics of the operation. Survey of methods for ordering equations. Discussion of process optimization for non-linear systems. Effects of uncertainty in process design.

302. Chemical Engineering Kinetics (3) fall
The application of chemical kinetics to the design and operation of reactors. Interrelations of kinetics, thermodynamics and unit operations. Prerequisites: Ch.E. 167 or 286, Ch.E. 210 or equivalent, previously or concurrently.

312. (Chem. 312, Met. 312) Fundamentals of Corrosion (3)
For description, see Chem. 312.

320. Waste Water Control (3) fall
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.

321. Fundamentals of Air Pollution (3) spring
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 Physical Sciences.

331. Distillation (3)
Design and operating strategies and techniques. Computer solutions for simple and complex, multicomponent distillation columns. Shortcut design methods. Tray hydraulics and constraints. Petroleum fractionators and azeotropic and extractive distillation.

340. Biochemical Engineering (3)
An introduction to various aspects of the utilization of industrially important bacteria, fungi, and yeasts. Biochemical activities and significant metabolic products of these microorganisms are discussed as are aspects of fermentor design. Consideration is given to product purification and end use. Two recitations and one laboratory period per week. Prerequisite: consent of chairman.

350. Special Topics (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. (M.E. 360) Nuclear Reactor Engineering (3)
See M.E. 360 for description.

380. Design Projects (1-6)
Design project work as a member of a team, preferably including students from differing disciplines. The project will attack a problem which, when possible, involves one of the local communities or industries. Specific projects will normally be guided by faculty from several departments with consultants from off the campus. The course will be offered both semesters and may be repeated for credit.

386. Process Control (3) fall
Laplace transformation and transfer functions, frequency response, feedback and feedforward control. Openloop and closedloop stability analysis using root locus and Nyquist techniques, design of feedback controllers with time and frequency domain specifications. Experimental process identification, introduction to sampled-data control theory. Prerequisite: Ch.E. 286 or equivalent.

390. (Chem 390) Polymer Synthesis and Characterization (1-3)
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: Chem. 51, 187, 191.

392. (Chem. 392) Polymer Science (3) spring
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: Chem. 187 or equivalent.

393. (Chem. 393, Met. 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 physical chemistry.

394. (Chem. 394) Organic Polymer Science (3) spring
Organic chemistry of synthetic high polymers. Functionality and reactivity of monomers and polymers. Theory of step-growth and chain-growth polymerization in homogeneous and heterogeneous media. Polymerization by addition, elimination, substitution and coupling reactions. Ionic fee-radical and coordinate catalysis. Prerequisite: one year physical chemistry and one year organic chemistry.

For Graduates

The department of chemical engineering is of moderate size, active in research and teaching emphasizing the theory of chemical processing operations. The teaching staff consists of twelve senior faculty members plus three locally employed engineers who serve as lecturers. The undergraduate enrollment has been stable over the past several years at a figure that produces about forty B.S. recipients each year. The graduate enrollment has grown markedly so that there now are thirty-five full-time graduate students enrolled in the department plus approximately an equal number of locally employed engineers who enroll for one or two graduate courses. The graduate students have come from many educational

institutions. Some of these are: M.I.T., R.P.I., Delaware, Rochester, Purdue, Drexel, Carnegie-Mellon, Newark College of Engineering, U.C.L.A., Case, Penn State, Virginia, Maryland, N.Y.U., and Tufts. Last year the department awarded nine M.S. degrees and four Ph.D. degrees.

Offerings of the department include courses in thermodynamics, reaction kinetics, transport processes, heat transfer, mass transfer, momentum transfer, process dynamics, and applied mathematics. In addition, more specialized courses in catalysis, cryogenic engineering, and polymer processing are offered on a rotating basis. The individual graduate student builds a program out of these courses plus additional work in mathematics, chemistry, physics, and other engineering as individual interests and goals dictate. The net result is a training extending the breadth and depth of understanding of the fundamentals of chemical engineering. There is very little additional material in specific applications or industries. Theses are chosen by the student according to individual interest, but usually are consistent with this basic departmental philosophy.

The research facilities of the department are continually being expanded and are adequate to support the research interests of the staff and graduate students. In addition to the research equipment directly available in the department, graduate students often find the CDC 6400 computer operated by the University's Computing Center a valuable research tool. Currently research is conducted in the fields listed below.

Thermodynamic Properties of Multicomponent Systems:
Joule-Thomson coefficients of gas mixtures
Latent heat of vaporization at high pressure
Phase equilibria
Specific heats and heats of solutions of liquid mixtures
PVT measurement
Measurement of the effect of pressure on heat capacity
Adsorption equilibria from gas mixtures on various substrates

Fluid Dynamics:
Retention studies in process equipment
Eddy diffusivity measurements
Process dynamics and response in flow systems
Turbulence in annular flow
Rheology of heavily doped suspensions
Viscoelastic properties of suspensions
Dynamics of film-splitting
Flow of non-Newtonian fluids

Heat and Mass Transfer:
Two-phase heat and momentum characteristics
Ice formation on cold surfaces
Pulsed extraction column performance
Mass transfer through dialysis membranes

Reaction Kinetics:
Immobilized enzyme catalysis
Kinetics of thermal decomposition of explosives
Reduction of metal oxides in plasmas
Ion exchange catalysis
Mechanism of explosion initiation
Catalysis in ortho-para hydrogen conversion
Influence of microstructure on gas adsorption and catalysis

Process Dynamics and Control:
Distributed parameter representation of engineering systems
Control systems for distillation columns with side-stream draw-offs
Frequency response of process systems
Digital simulation of chemical process systems
Optimization of absorber operation
Feed-forward control of distillation columns
Computer control of process equipment

Polymer Science:
Morphology of polymer crystallization from solution
Characteristics of heterogeneous polymer systems
Interpenetrating polymer networks (IPN's)
Constrained layer damping with IPN's
Polymer-concrete system applications
Emulsion polymerization mechanisms
Diffusion through polymer films

The department is located in Whitaker Laboratory. In this building some 40,000 square feet of space is available for the research, teaching, and office needs of the department. The building is air conditioned, and includes specially designed facilities for analog computation, calibration standards, process dynamics study, reaction kinetics and thermodynamics research, nuclear engineering, high pressure research, and a wide range of general research space.

In addition to activities that are traditionally chemical engineering, the department cooperates with several other campus groups to offer interdisciplinary programs. At present these include a program in chemical metallurgy carried on in cooperation with the department of metallurgy and materials science, a program in polymer science through cooperation with the Polymers Research Laboratory of the Materials Research Center, a program in water resources through cooperation with the departments of civil engineering and biology, research in interfacial phenomena through the Center for Surface and Coatings Research, and air and water pollution with the Center for Marine and Environmental Studies.

Of these, the most completely formulated is the chemical metallurgy program. Though Ph.D. programs are available, this program is basically M.S.-oriented. Graduates should be uniquely prepared to contribute to the metal refining industry. The program includes industrial exposure as well as a carefully selected sequence of courses and research topic. Study in this program is underwritten by several industrial concerns. Students having an interest in this area should write for a descriptive brochure.

A cooperative M.S. program has been initiated for those specially interested in careers in design. An individually tailored course sequence is coupled with a design project which replaces the more conventional M.S. research project. In order to assure complete support of the design work, and a professional evaluation of it, this project is done within the process design group of one of several nearby design engineering companies. The student is supported by the host company.

Arrangements have been made with Air Products and Chemicals, Inc., and with Bethlehem Steel Corporation to allow a graduate student in chemical engineering to engage in part-time employment in their research or engineering departments. Both of these installations are within easy driving

distance of the Lehigh campus, and in both places the student would receive experience in the most advanced work being done in the industry. Typically, a student would work 20 hours per week and would receive pay equivalent to that of a teaching assistant. This would allow the person to enroll for about ten hours of graduate course work per semester, and to progress toward the M.S. degree at a rate equivalent to that of a teaching or research assistant.

Opportunities for financial support during graduate studies are varied, depending upon individual interests and needs. However, they are limited in number, and cannot be offered to more than a few qualified applicants. See the Graduate School section for details. The time required for an M.S. degree can vary from twelve months to two years depending upon the type of support and the preparation, diligence, and ability of the student. A Ph.D. degree is obtainable in a minimum of 36 months, but more normally requires four years.

400. Chemical Engineering Thermodynamics I (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. Mr. Stein.

401. Chemical Engineering Thermodynamics II (3) spring
A detailed study of the uses of thermodynamics in predicting phase equilibria in solid, liquid, and gaseous systems. Fugacites of gas mixtures, liquid mixtures, and solids. Solution theories; uses of equations of state; high-pressure equilibria. Mr. Stein.

410. Chemical Engineering Kinetics (3)
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: Ch.E. 302.

413. Heterogeneous Catalysis (3)
Surface area, pore structure and pore-size distribution of catalysts. Influence of pore-diffusion on catalytic reactions and the design of catalytic reactors. Chemical adsorption and physical adsorption. Chemistry, energetics and kinetics of adsorption, desorption, and surface reaction. Electronic structure and catalysis; atomic orbital and bondstructure models. Mechanisms of catalytic reaction of industrial importance. Selection and classification of catalysts. Mr. Coughlin.

415. Transport Processes (3)
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.

421. Heat Transfer (3)
Analysis of steady and unsteady state transfer. Convection, conduction, and radiation. Vaporization and condensation. Heat transfer in high velocity flow and in rarified gases. Applications. Mr. Foust.

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.

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.

440. Process Design (3)
Synthesis of flow sheets for various processes, investigation of contributions to over-all economy of various alternatives. Evaluation of profitability of alternatives.

441. Advanced Process Control (3)
Sampled-data control theory with applications in digital computer control systems. Nonlinear methods of dynamic analysis. Optimal control via calculus of variations and the maximum principle. Mr. Luyben.

450. Special Topics (3-12)
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.

461. Mathematical Methods in Chemical Engineering I (3)
Application of ordinary and partial differential equations to the solution of chemical engineering problems with emphasis on chemical reactions and transport processes as they occur in industrial chemical processing. Applications of solution in series, separation of variables, and integral transforms. Prerequisite: Math. 322.

464. Numerical Methods in Engineering (3) fall

Applied computer-oriented mathematics including linear difference operators, interpolation polynomials, numerical quadrature based on the Newton Cotes open and closed formulas, matrices and linear algebra with emphasis on the solution of large sparse systems, algorithms for nonlinear algebraic and transcendental systems. Computer solution of problems selected from a number of scientific and engineering disciplines. Mr. Schiesser.

465. Numerical Methods in Engineering (3) spring
A continuation of Ch.E. 464 with emphasis on the numerical integration of ordinary and partial differential equations. Topics include: single step and multistep algorithms for initial value problems in ordinary differential equations, error monitoring and control, stability and the integration of stiff systems, geometric classification of partial differential equations, explicit and implicit finite difference algorithms, convergence, consistency and stability. Mr. Schiesser.

470. Cryogenic Engineering (3)
Liquefaction and separation of gases, physical and chemical principles. Low temperature thermometry. Insulation. Properties of fluids and of structural materials. The behavior of helium. Ultra-low temperature phenomena and theories. Mr. Wenzel.

471. Low Temperature Processes (3)
The problems and design of plants operating in the cryogenic temperature range. Refrigeration demands. Distillation and heat exchange at low temperatures. Analysis of processes for thermodynamic and operating efficiency. Problems of safety, non-steady state behavior and control. Mr. Wenzel.

480. Research (3-4)
Investigation of a problem in chemical engineering.

481. Research (3-4)
Continuation of Ch.E. 480.

492. (Chem. 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: Chem. 392 or equivalent.

Chemistry

Professors

Frederick Mayhew Fowkes, Ph.D., *Chairman*
Albert Charles Zettlemoyer, Ph.D. *Distinguished Professor, Vice President and Provost*
Eugene Murray Allen, Ph.D.
Thomas C. Cheng, Ph.D., *Director, Center for Health Sciences*
Charles Stephen Kraihanzel, Ph.D.
Henry Leidheiser, Jr., Ph.D., *Director, Center for Surface and Coatings Research*
Ned D. Heindel, Ph.D.
Kamil Klier, Ph.D.
John Alexander Manson, Ph.D., *Director of the Polymer Laboratory, Materials Research Center*
Joseph Robert Merkel, Ph.D.
William Edward Ohnesorge, Ph.D.
Donald Morgan Smyth, Ph.D., *Director, Materials Research Center*
Robert Stacy Sprague, Ph.D.
James Edward Sturm, Ph.D.
John W. Vanderhoff, Ph.D., *Associate Director, Center for Surface and Coatings Research*
Thomas Edwin Young, Ph.D.

Associate Professors

Roland William Lovejoy, Ph.D.
Fortunato Joseph Micale, Ph.D.
Gary W. Simmons, Ph.D., *Assistant to the Director, Center for Surface and Coatings Research*
Daniel Zeroka, Ph.D.

Assistant Professors

Matthew Harold Hulbert, Ph.D.
Robert S. Rodgers, Ph.D.
Stephen W. Schaffer, Ph.D.
Keith J. Schray, Ph.D.

Chemistry is a basic science of such intellectual challenge that most graduates continue study for advanced degrees, yet it is so practical that 200,000 chemists provide the technical backbone of the manufacturing industries. Students majoring in chemistry receive an education which provides a broad base for further specialization in a wide variety of careers. A degree in chemistry (with biology electives) is the strongest preparation for medical school, and an excellent background for graduate studies in other health-related disciplines (biochemistry, pharmacology, immunology, pathology, etc.). Graduate schools gladly accept chemistry majors into a variety of other programs (physics, material science, oceanography, environmental studies, mineralogy, etc.). Within the

field of chemistry, graduates are prepared for research (in universities, government laboratories, or industrial laboratories), for teaching (in universities, colleges, or high schools), for industrial positions (in product development, sales, or management) and for government positions (pollution control, Food and Drug Administration, etc.). Most chemists are employed in manufacturing industries (pharmaceuticals, plastics, fibers, rubber, paper, coatings, electronics, materials, automobiles, aircraft, petroleum, agricultural chemistry, etc.) and in many of these industries chemists rise to top management positions.

The undergraduate curriculum in chemistry contains many of the prerequisites for biology, geology, metallurgy, physics, and chemical engineering so that students can easily transfer with no loss of credits, even in the junior year.

Chemistry students have the opportunity to design their undergraduate curriculum for specialization in a variety of fields:

Health-Related Chemistry (including premedical students)

Suggested biology electives: 21, 22, 35
Suggested chemistry electives: 336, 352, 371, 372, 377, 378
Suggested physics elective: 367
The above electives may be used in place of Math. 205 and German.

Materials Chemistry (polymer, solid state, surface)

Suggested physics electives: 31, 363
Suggested chemistry electives: 312, 390, 392, 393, 394, 396, 397
The above electives may be used in place of German.

Environmental Chemistry

Suggested biology electives: 21, 22, 35
Suggested chemical engineering electives: 320, 321
Suggested chemistry electives: 303, 334, 397, 310
The above electives may be used in place of Math. 205 and German.

Geochemistry

Suggested geology electives: 333, 334, 336, 352, 372
Suggested chemistry electives: 303, 396
The above electives may be used in place of Math. 205 and German.

Chemistry Management

Suggested mathematics substitution: 231 for 205 (permits B.S. plus M.B.A. in five years)
Suggested accounting electives: 108, 111
Suggested law elective: 101
Suggested management electives: 201, 302
Suggested chemistry electives: 390, 392, 397
The above electives may be used in place of German.
Suggested economics electives: 129, 206
Suggested marketing elective: 211
Suggested finance elective: 225

Accelerated programs

A three-year B.S. degree and a four-year M.S. degree are available as part of the six-year B.S. and M.D. plan of Lehigh and Hahnemann Medical College. See course description for Health Professions. Eligibility is limited to students entering the university with credit for Chemistry 21 and 22.

The Five-Year Program

Five-year programs are available for students to receive B.S. or B.A. degrees and an M.S. degree in several fields of chemistry (inorganic, organic, analytical, or physical chemistry, polymers, or biochemistry). A five-year program is also available for a B.S. degree in chemistry and a master's degree in business administration (M.B.A.).

Bachelor of arts and bachelor of science majors

Lehigh University offers a B.A. degree in chemistry from the College of Arts and Science and a B.S. degree in chemistry from the College of Engineering and Physical Sciences. In most classes, the B.S. candidates outnumber the B.A. candidates in chemistry, but not always. The required courses in science and mathematics are identical for the two programs; these are shown in the recommended sequence of courses for the B.S. degree. The difference in the two programs lies in the distribution of courses in the humanities and social sciences. Candidates for either the B.A. or B.S. degrees need not take language courses, although German is strongly recommended. The minimum number of semester hour credits needed for graduation is 120 for the B.A. degree and 122 for the B.S. degree, but a larger number is recommended (128 semester hours is considered normal for the B.S. degree; see description of the normal program in the College of Engineering and Physical Sciences section.)

Recommended Sequence of Courses for the B.S. Degree

Freshman Year (See page 52)

Sophomore Year, First Semester (16 credit hours)

Chem 51	Organic Chemistry (3)
Chem 53	Organic Chemistry Lab (1)
Phys 21	Introductory Physics (4)
Phys 22	Introductory Physics Lab II (1)
Math 23	Analytical Geometry and Calculus III (4)
	GS Requirement in Social Science (3)

Sophomore Year, Second Semester (14-17 credit hours)

Chem 31	Chemical Equilibria (3)
Chem 52	Organic Chemistry (3)
Chem 54	Organic Chemistry Lab (2)
Ger 1	Elementary German (or approved substitutes) (3)
Math 205	Linear Methods (or approved substitute) (3)
	Elective (0-3)

Junior Year, First Semester (16 credit hours)

Chem 187	Physical Chemistry (3)
Chem 234	Analytical Chemistry Lab (1)

Chem 332	Analytical Chemistry (3)
Chem 358	Advanced Organic Chemistry (3)
	Electives (0-3)
Ger 2	Elementary German (or approved substitute) (3)
	GS Requirement (3)

Junior Year, Second Semester (15-18 credit hours)

Chem 188	Physical Chemistry Lab (2)
Chem 191	Physical Chemistry (3)
Eco 1	Economics (4)
	GS Requirement (6)
	Electives (0-3)

Senior Year, First Semester (15-18 credit hours)

Chem 307	Inorganic Chemistry (3)
Chem 383	Advanced Chemical Experimentation (4)
Chem	Elective (2-3)
	Elective (6)

Senior Year, Second Semester (14 credit hours)

Chem 381	Radiation and Structure (3)
Chem	Elective (2-3)
	Electives (9-12)

Chemistry electives are any two courses (200 to 400 level) in science or engineering; at least one must include a laboratory.

Undergraduate Courses

21. Introductory Chemical Principles (4) fall-spring
An introduction to certain important principles of chemistry. Topics include atomic structure and bonding, stoichiometry, states of matter, and introductions to kinetics, chemical equilibrium, acid-base theories, oxidation-reduction reactions, and galvanic cells. Math. 21, 31, or 41 previously or concurrently. Two lectures, two recitations. Messrs. Sprague or Kraihanzel.

22. Chemical Principles Lab (1) fall-spring
A laboratory course to be taken concurrently with Chemistry 21. An introduction to chemical laboratory techniques with emphasis on quantitative measurements. One three-hour laboratory period per week. Messrs. Sprague or Kraihanzel.

23. Earth, Air, Fire, and Water (3) spring
A study of chemical principles underlying the impact of society on the quality of our environment, particularly of air and water. Emphasis is on examples in inorganic chemistry. Prerequisite: Chemistry 21 or exemption from Chemistry 21 by examination. Two lectures, one two-hour demonstration period. Messrs. Ohnesorge or Rodgers.

31. Chemical Equilibria in Aqueous Systems (3) fall-spring
Mass law calculations involving acid-base, solubility, complexation and oxidation-reduction equilibria in aqueous solution. Introduction to the thermodynamics of chemical systems. Descriptive chemistry of familiar representative elements and certain of the transition metal elements with emphasis on behavior in aqueous systems. The laboratory work emphasizes qualitative and quantitative analysis. Prerequisites: Chem 21, Math 21, Physics 11. Two lectures, one three-hour recitation-lab period per week. Mr. Sprague.

39. Analytical Chemistry (3) spring
The fundamentals, theory, and practice of analytical chemistry for all students except chemistry majors. Selected topics in the areas of classical and instrumental analysis. Fundamental techniques are presented in the laboratory. Two lectures, one laboratory period. Prerequisite: Chem. 21. Messrs. Ohnesorge or Rodgers.

51. Organic Chemistry (3) fall
Systematic survey of the typical compounds of carbon, their classification, and general relations; study of synthetic reactions. Prerequisite: Chem. 21. Messrs. Heindel, Schray, or Young.

52. Organic Chemistry (3) spring
Continuation of Chem. 51. Prerequisite: Chem. 51.

53. Organic Chemistry Laboratory (1) fall
Preparation of pure organic compounds. Prerequisite: Chem. 21. Messrs. Heindel, Schray, or Young.

54. Organic Chemistry Laboratory (2) spring
Continuation of Chem. 53 with particular emphasis upon aromatic compounds and qualitative organic analysis. Prerequisite: Chem. 53 previously; Chem. 52 concurrently. Messrs. Heindel, Schray, or Young.

55. Organic Chemistry Laboratory (2) spring
A course in the preparation of pure organic compounds and the techniques of organic chemistry applicable to both aliphatic and aromatic compounds. Prerequisites: Chem. 51 and Chem. 52 concurrently. Messrs. Heindel, Schray, or Young.

187. Physical Chemistry (3) fall
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. Discussion of various states of matter (gases, liquids, solids, interfaces). Prerequisites: Chem. 21; Math. 23, previously or concurrently. Mr. Lovejoy.

188. Physical Chemistry Laboratory (2) spring
Primarily for majors in chemistry. Quantitative observation of properties of matter and of dynamic processes involving composition, the relation of observations to conceptual models. Methods of data acquisition, treatment, assessment. Two three-hour labs per week. Prerequisite: Chem. 187. Mr. Sturm.

191. Physical Chemistry (3)
Quantum chemistry of bonding and molecular structure. Elements of statistical thermodynamics. Prerequisites: Chem. 21, Math. 23, Phys. 21. Messrs. Lovejoy or Zeroka.

192. Physical Chemistry Laboratory (2) fall
This course provides a series of laboratory studies which illustrate the various fields of study in experimental physical chemistry. Prerequisite: Chem. 187. Mr. Sturm.

194. Physical Chemistry for Biological Sciences (3) spring
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: Chem 21. Mr. Fowkes.

196. Physical Chemistry (3) fall
Primarily for majors in metallurgical engineering. (Not for chemistry or chemical engineering students.) Kinetic theory and chemical kinetics; electrochemistry; topics in surface chemistry and solid state chemistry. Prerequisite: Chem 21. Messrs. Sturm or Lovejoy.

234. Analytical Chemistry Laboratory (1)
Laboratory course: experiments coordinated with and illustrating methods and principles discussed in Chem. 332. Messrs. Ohnesorge and Rodgers.

250. Special Topics (3)
Selected topics in chemistry not included in other courses. Prerequisite: consent of chairman.

300. Apprentice Teaching in Chemistry (1-3)

303. Nuclear and Radiochemistry (3) fall
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. Mr. Sturm.

306. Inorganic Laboratory (2)
A laboratory course illustrating a variety of techniques for the preparation and purification of inorganic compounds. Hours equivalent to two laboratory periods per week will be arranged by the instructor. Prerequisite: Chem. 307, 383. Mr. Kraihanzel.

307. Advanced Inorganic Chemistry (3) fall
Selected topics in inorganic chemistry. Descriptive chemistry of the representative elements; introduction to transition metal complexes and the theories of bonding in these substances; kinetics and mechanisms of transition metal complex reactions; selected aspects of organometallic chemistry; bioinorganic chemistry. Prerequisite: Chem. 191. Messrs. Kraihanzel or Sprague.

310. Instrumentation Principles I (3) fall
A study of electrical, electronic, and optical principles in modern instrumentation for measurement and control. Principles and applications of semiconductors with associated circuitry applied to modern instrumentation. Transducer application to fields of electrical, optical and mechanical measurement. Two lectures and one three-hour laboratory. Mr. Rodgers.

311. Instrumentation Principles II (3) spring
A continuation of Chem. 310 with emphasis on applications and utilization of digital electronics. The development of the complete instrument including optical instrumentation. Two lectures and one three-hour laboratory. Prerequisite: Chem. 310 or equivalent. Mr. Rodgers.

312. (Ch.E. 312, Met. 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: Met 210, Chem 187, or equivalent. Messrs. Leidheiser or Smyth.

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. Prerequisite: Chem. 31 and 51. Messrs. Ohnesorge or Rodgers.

334. Chemical Oceanography (3)
Chemistry of the oceans and other natural water systems, with emphasis on processes occurring at the interfaces with the air, the sediments, the rivers, and living organisms. Optional cruise. Prerequisite: two chemistry courses or consent of chairman.

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. Prerequisite: Chem. 39 or Chem. 332 and Chem. 52. Messrs. Ohnesorge and Rice.

350. Special Topics (3)
Selected advanced topics in chemistry not included in other courses. Prerequisite: consent of department chairman.

356. Quantitative Organic Analysis (1)
Quantitative analysis of organic compounds. One laboratory period per week. Prerequisites: three hours of analytical chemistry; a course in organic chemistry.

358. Advanced Organic Chemistry (3) fall
The study of modern theories of reaction mechanisms and their applications to the problems of organic chemistry. Prerequisite: one year of organic chemistry. Messrs. Heindel or Young.

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. (Biol. 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. Messrs. Merkel or Schaffer.

372. (Biol. 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: Chem. 371. Messrs. Merkel or Schaffer.

375. Research Chemistry Laboratory (3) fall-spring
Advanced independent study or an investigation involving intensive work with faculty guidance in laboratory and library. Topics in active research in biochemistry, analytical, inorganic, organic, and physical chemistry. Prerequisite: consent of chairman.

377. Biochemistry Laboratory (2) 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: Chem. 371, previously or concurrently. Messrs. Merkel or Schaffer.

378. Biochemical Preparations (2) spring
A laboratory course involving the preparation or isolation, purification and identification of chemicals of biological origin. Prerequisite: Chem. 377 and 372, previously or concurrently. Messrs. Merkel and Schaffer.

381. Radiation and Structure (3) spring
Quantum chemistry and group theory applied to molecular orbital theory of bonding and structure and to spectroscopy: X-ray, electron, luminescence, Raman, microwave. Prerequisites: Chem. 191 and 332. Messrs. Fowkes, Ohnesorge, and Zeroka.

382. Electrochemistry and Kinetics (3-4) fall
A unified study of matter in the process of change. Elements of irreversible thermodynamics; electrochemistry; chemical kinetics; electrokinetic phenomena. Three one-hour lectures and (optional) three-hour laboratory. Prerequisite: Chem. 187 and 332. Messrs. Rodgers and Sturm.

383. Advanced Chemical Experimentation (4) fall
An advanced lecture-laboratory course which requires the student to interrelate and coordinate facts and experimental techniques covered in prior chemistry courses. This correlation will be utilized by the student in synthesis, separation, purification, characterization, and analysis of selected organic and inorganic compounds. One lecture and three laboratory meetings per week. Prerequisite: Chem. 188, and Chem. 307 previously or concurrently. Mr. Kraihanzel.

390. Polymer Synthesis and Characterization (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: Chem. 187, Chem. 191, and Chem. 51. Mr. Manson.

392. (Ch.E. 392) Introduction to Polymer Science (3)
For course description, see Ch.E. 392.

393. (Ch.E. 393. Met. 343) Physical Polymer Science (3) fall
For course description, see Ch.E. 393.

394. (Ch.E. 394) Organic Polymer Science (3) spring
Organic chemistry of synthetic high polymers. Functionality and reactivity of monomers and polymers. Theory of step-growth and chain-growth polymerization in homogeneous and heterogeneous media. Polymerization by addition, elimination, substitution, and coupling reactions. Ionic, free-radical, and coordination catalysis. Prerequisite: one year of physical chemistry and one year organic chemistry. Messrs. Manson and Vanderhoff.

396. Solid State Chemistry (3) spring
Chemistry of ionic and electronic defects in solids and their influence on chemical and physical properties. Intrinsic and impurity-controlled defects, non-stoichiometric compounds, ordering of defects at surfaces and interfaces. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, photoconductivity, rectifying junctions, chemisorption, and catalysis. Prerequisite: Chem. 184 or Met. 210 or equivalent. Mr. Smyth.

397. 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 charge transport in colloidal suspensions, electrostatic and London forces in disperse systems, gas adsorption, and heterogeneous catalysis. Prerequisite: Chem. 187 or equivalent. Mr. Fowkes.

For Graduates

The department of chemistry offers graduate studies leading to several different advanced degrees. In addition to the traditional M.S. and Ph.D. degrees in chemistry, the department also offers a D.A. (doctor of arts) degree in chemistry (primarily for college-level chemistry teachers), an M.S. and Ph.D. degree in physiological chemistry (primarily for certain specialties in the health sciences), and an M.S. and Ph.D. degree in molecular biology.

The department is large and is housed in several buildings.

During 1975, most of the department will be relocated in the new $7 million chemistry complex (an auditorium building and a laboratory building). The laboratories are located in the Seeley G. Mudd Building, the top three floors of which are devoted to research laboratories. Most of the research in surface studies is located in the adjacent Sinclair Laboratory, which houses the Center for Surface and Coatings Research. Physiological chemistry is located on the ground floor of Chandler Laboratory. Some of the solid state research will be housed in the Sherman Fairchild Laboratory for Solid State Studies, which will be under construction during 1975-76, and some of the polymer research is located in Coxe Laboratory (Materials Research Center) and in Whitaker Laboratory (chemical engineering department).

The University libraries contain approximately 650,000 volumes and currently subscribe to some 6,000 serials and periodicals. There are particularly strong collections available for research in the physical and natural sciences.

The graduate program in chemistry at Lehigh has a two-fold purpose. It affords a student the opportunity to acquire a modern advanced knowledge of chemistry within the framework of formal graduate courses and permits the development of techniques required of competent research through independent scientific investigation. The graduate program for the Ph.D. degree in chemistry consists of approximately one-third formal course work and two-thirds independent research and study. A student entering upon graduate study with a teaching assistantship will spend an average of four years of full-time residency beyond the bachelor's degree to complete all the requirements for the Ph.D. degree.

During the first year of graduate work a student normally takes basic graduate courses from the fields of analytical, biological, inorganic, organic, and physical chemistry and becomes acquainted with the research interests of the various faculty members. From these contacts the student is able to assess critically an individual research interest, and thus choose a research director. Having selected a research director, a research problem is mutually agreed upon; a thesis committee is appointed to serve in an advisory capacity.

It is assumed that an entering graduate student in chemistry will have satisfied the requirements for the bachelor's degree that meet the minimum standards recommended by the American Chemical Society Committee on Professional Training. Thus, in addition to the usual chemistry courses, a student's undergraduate curriculum should include at least one year of physics, mathematics through calculus, and preferably at least one year of German. If a student shows a deficiency in one or more of these undergraduate areas, these can be rectified during the first year of graduate work and do not affect a student's eligibility for an appointment to an assistantship.

Teaching and research assistantships, as well as fellowships, are available to graduate students in chemistry. The assistantships are regarded as half-time appointments, permitting a student to enroll for up to ten credit hours of course work per semester. Students on teaching appointments normally have an average of eight hours per week of instructional duties in undergraduate recitation classes or laboratories. The University does not charge tuition or other fees of students on teaching appointments.

At present, forty students are enrolled in graduate studies in chemistry. About half have teaching assistantships or fellowships and half have research assistantships. The department has annual research funding of about $500,000, largely in the fields of polymer, solid state, and surface chemical research. Medicinal chemistry and radiopharmacology are also well funded, and so is physiological chemistry. Students specializing in these fields will have the best chance of research assistantships during the 1975-77 period.

Current research projects of interest are listed below.

Analytical Chemistry. Electrochemical reduction and oxidation mechanisms of organic compounds, luminescence of metal chelates, voltammetry in non-aqueous solvents, clinical-biomedical applications, mechanisms of electrode processes, adsorption, chemistry of amalgams.

Biochemistry. Production, isolation and characterization of proteolytic enzymes of marine bacteria; determination of the amino acid specificity of bacterial proteases; mechanism of action of proteolytic enzymes, cardiac metabolism and enzymology; enzyme kinetics; protein structure and reconstitution; sugar phosphate substrate utilization by glycolytic enzymes; mechanism of phosphoglucose isomerase and aldolase; phosphoryl transfer reactions of enzyme.

Inorganic chemistry. Synthesis and characterization of amide complexes of transition metals; silicon organometallic compounds; substitution and rearrangement reactions involving metal carbonyls; organic syntheses and catalysis involving transition metal complexes.

Organic chemistry. Synthesis of medicinal agents; correlation of molecular structure with pharmacological behavior; chemical models for biochemical reactions; sulfur bonding in novel heteroaromatic sulfur compounds; biosyntheses involving indole intermediates; mechanism of formation and structure of melanin; synthesis of new heterocyclic systems; mechanisms of phosphoglucose isomerase and aldolase; synthesis and phosphoryl transfer of phosphate esters of biological interest.

Physical chemistry. Lehigh is internationally famous for surface and colloid chemistry (gas adsorption, heterogeneous catalysis and nucleation, surface calorimetry, surface spectroscopy, surface analysis, principles of wettability, colloidal stability, latexes and surface coatings); most of these studies are housed in Sinclair Laboratory; Lehigh is also prominent in solid-state chemistry (electrically charged point defects in oxides, mechanisms of oxide film growth, spectroscopy of zeolites, and equilibria of point defects in oxides); part of these studies will be housed in the new $1.4 million Sherman Fairchild Laboratory for Solid State Studies; other fields of strength include the physical chemistry of polymers, flash photochemistry and kinetic spectroscopy, structure determination (bond lengths and angles) of gaseous compounds from vibration-rotation spectra using infra-red spectroscopy, and applications of quantum mechanics and statistical mechanics to problems of chemical interest.

Polymer chemistry. Lehigh staff members are well recognized nationally and internationally in several aspects of the 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.

Special equipment available for graduate research in chemistry includes a computer terminal in the chemistry building, electron microscope, scanning electron microscope, electron microprobe, optical microscopes, precision mass spectrometer, nuclear magnetic resonance spectrometer, electron spin resonance spectrometer, various double-beam infra-red, visible, and ultraviolet spectrometers, Fourier transform infrared interferometer, atomic absorption spectrometers, spectrofluorometers, phosphorescence spectrometer, Auger spectrometer, Mossbauer spectrometer, automatic multichannel scintillation counter, radiotracer equipment, flash photolysis apparatus, light-scattering photometer, ultracentrifuges, analytical and preparative gas chromatographs, Vibron elastoviscometer, Weissenberg rheogoniometer, differential scanning calorimeter and other thermoanalytical equipment, gel permeation chromatograph, torsional modulus apparatus, vapor and liquid permeability equipment, dielectric capacitance bridges, MTS closed-loop hydraulic tester, torsion tensile testers, high temperature tube furnaces, capacitance-voltage testing equipment, cobalt-60 gamma ray source, Wenking potentiostat, recording-multipurpose polarographs, and chronopotentiometers, high speed centrifuges, automatic fraction collectors, freeze dryers, high voltage electrophoreses apparatus, electron microscope, laboratory fermentor, walk-in cold room, cell disintegrator, Warburg respirometer, zone and disc electrophoresis apparatus, paper column chromatography equipment, freeze-dryer, autoclave.

402. Physical Inorganic Chemistry (3) alternate years
Theories of bonding. Group theoretical principles will be utilized in studies of molecular orbital and ligand field theories of bonding. Prerequisite: Chem. 191 or equivalent. Mr. Klier.

403. Advanced Topics in Inorganic Chemistry (3) alt. yrs.
Topics of contemporary interest in inorganic chemistry. This course may be repeated when a different topic is offered. Prerequisite: Chem. 307 or equivalent. Messrs. Klier, Kraihanzel, and Sprague.

405. Organometallic Chemistry (3) alternate years
The chemistry of compounds containing carbon to metal bonds. Among the topics to be covered are the following: organic compounds of the representative elements from Groups I-IV; the chemistry of ferrocene and related pi-bonded organometallic complexes; metal carbonyl and nitrosyl complexes; dioxygen and dinitrogen complexes; organic syntheses utilizing organometallic catalysts. Prerequisites: Chem. 307 and Chem. 358. Mr. Kraihanzel.

407. Mechanisms of Inorganic Reactions (3) alternate years
A study of the experimental and theoretical evidence for the following types of inorganic reaction mechanisms: proton transfer and Bronsted acid-base catalysis, nucleophilic and electrophilic displacements, Lewis acid-base catalysts, electron and atom transfer in oxidation-reduction reactions, free radical reactions, elimination reactions. Emphasis is on homogenous reactions in solution or the gas state. Mechanisms involving both transition and non-transition elements will be discussed. Prerequisite: Chem. 307 or equivalent. Mr. 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. Observation and evaluation of the intern will be effected by classroom visits and videotape review. Prerequisite: candidacy in the D.A. program or permission of the chairman. 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.

432. Advanced Analytical Chemistry (3) alternate years
Recent developments in analysis by 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: Chem. 332 or equivalent. Messrs. Ohnesorge and Rodgers.

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: Chem. 332 or equivalent. Mr. Rodgers.

436. Advanced Methods of Analytical Chemistry (3) alt. yrs.
Theory and analytical applications of selected spectroscopic techniques: e.g., luminescence, magnetic resonance, and microwave spectroscopy. Prerequisite: Chem. 381 or Chem. 445, or equivalent. Messrs. Ohnesorge and Rodgers.

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, adsorption and catalysis. Prerequisite: one year of physical chemistry. Mr. Sturm.

443. (Met. 443) Solid State Chemistry (3) alt. yrs.
Crystal structure, diffraction in crystals and on surfaces, bonding and energy spectra in solids, dielectrics, surface states and surface fields in crystals. Prerequisite: Chem. 191 or equivalent. Mr. Klier.

445. Elements of Physical Chemistry (4) fall
Quantum chemistry of simple systems, molecular structure and spectroscopy, statistical and classical thermodynamics, and principles of kinetic processes. Messrs. Fowkes, Lovejoy, Sturm, and Zeroka.

447. (Biol. 447) Experimental Molecular Biology (3)
See Biology 447 for description.

450. Theoretical Organic Chemistry (3) alternate years
An advanced study of topics in theoretical and mechanistic organic chemistry: solvolyses, rearrangements, multi-center reactions, carbenes, photochemistry and the application of nuclear magnetic resonance to organic chemical problems. Mr. Young.

451. Theoretical Organic Chemistry (3) alternate years
The chemistry of benzenoid aromatic compounds, quinones and non-benzenoid aromatic substances, including modern theories of structure, electrophilic, nucleophilic and homolytic aromatic substitution and the less familiar addition reactions of aromatic systems. Prerequisite: Chem. 358. Mr. Heindel.

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: Chem. 358. Mr. Young.

458. Topics in Organic Chemistry (3)
An intensive study of limited areas in organic chemistry. May be repeated when a different topic is offered. Messrs. Young, Heindel, and Schray.

466. Advanced Organic Preparations (2-3)
A laboratory course of instruction in advanced techniques of the preparation of organic compounds.

471. Natural Products (3) alternate years
A survey of the chemistry of steroids, terpenes, alkaloids and antibiotics with emphasis on instrumental methods of analysis and structure proof, recent synthetic and biosynthetic pathways.

476. Microbial Biochemistry (3)
Composition, nutrition and metabolism of micro-organisms, with emphasis on microbial enzyme reactions and products of microbial metabolism. Prerequisites: Chem. 372 and Biol. 35 or their equivalents. Mr. Merkel.

477. Topics in Biochemistry (3)
Intensive study of selected areas of biochemistry, such as mechanisms of enzyme action, new developments in the chemistry of lipids, nucleic acids, carbohydrates and proteins. Prerequisite: consent of department chairman. Mr. Schaffer.

479. Biochemical Techniques (1-3)
Laboratory studies of the techniques and principles involved in the isolation, identification and biochemical transformation of carbohydrates, lipids, nucleic acids and proteins. Prerequisite: Chem. 371 or its equivalent, previously or concurrently. Messrs. Merkel and Schaffer.

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 department chairman. Messrs. Merkel and Schaffer.

481. Chemistry Seminar (1-6) fall-spring
Reports and discussions of recent developments in chemistry.

492. (Ch.E.492) Topics in Polymer Science (3)
For course description, see Ch.E. 492.

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: Chem. 445 or consent of department chairman. Mr. Zeroka.

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. Mr. Zeroka.

497. Topics in Colloid and Surface Chemistry (3)
Applications of colloid chemistry; special topics in surface chemistry. Lectures and seminar. Prerequisite: Chem. 397. May be repeated for credit as different topics are covered. Messrs. Fowkes, Vanderhoff and Zettlemoyer.

498. Advanced Topics in Physical Chemistry (3)
An advanced study of some field of physical chemistry. Rotation-vibration spectroscopy; theory of solutions; photochemistry and radiation chemistry; irreversible thermodynamics or other topics of current interest.

Civil Engineering

Professors

David Alan VanHorn, Ph.D., *Chairman*
Lynn Simpson Beedle, Ph.D., *Director, Fritz Laboratory*
George Clarence Driscoll, Jr., Ph.D.
John William Fisher, Ph.D.
John Orth Liebig, Jr., M.S.
Le-Wu Lu, Ph.D.
Alexis Ostapenko, Ph.D.
Adrian F. Richards, Ph.D.
Lambert Tall, Ph.D.

Associate Professors

Arthur William Brune, Ph.D.
Wai-Fah Chen, Ph.D.
John Hartley Daniels, Ph.D.
George Anson Dinsmore, M.S.
Hsai-Yang Fang, Ph.D.
Terence John Hirst, Ph.D.
Ti Huang, Ph.D.
Robert Leroy Johnson, Ph.D.
Celal Nizamettin Kostem, Ph.D.
Roger George Slutter, Ph.D.
Bung-Tseng Yen, Ph.D.

Assistant Professors

Willard Austin Murray, Ph.D.
Paul John Usinowicz, Ph.D.

Civil engineering, the stem from which have branched the other types of engineering, is concerned with projects which contribute to the comfort and needs of the human race. The professional practice of a civil engineer includes the conception, design, construction, operation, and maintenance of private and public projects, including bridges, buildings, highways, airports, railroads, harbors, docks, subways, tunnels, water supply and purification systems, sewage collection and treatment facilities, water power developments, the making of surveys, and research. Many civil engineers are associated with consulting engineering firms, contractors, industrial concerns, or various governmental agencies.

In the undergraduate program, the work of the first two years deals chiefly with the scientific and mathematical principles which form the bases of engineering practice. The last two years include the applications of these principles, along with opportunities for elective courses in areas of individual interest. All students receive instruction in engineering measurements, soil mechanics, fluid mechanics and hydraulics, structural theory and design, transportation engineering and environmental engineering.

Engineers, through their professional societies, have urged that the engineering student be educated as a professional person with a sound understanding of one's place in society. This education is provided through a well-planned civil engineering program enriched by the humanistic-social courses taken during the four years, and selected with the advice and approval of the curriculum director.

Recommended Sequence of Courses

Freshman Year (See page 52)

Sophomore Year, First Semester (15 credit hours)

Math 23	Analytic Geometry & Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
Mech 1	Statics (3)
CE 13	Civil Engineering Concepts (3)

Sophomore Year, Second Semester (16 credit hours)

Math	Elective (3)
CE 40	Principles of Surveying (3)
Eco 1	Economics (4)
Mech 11	Mechanics of Materials (3)
	GS Requirement (3)

Summer (3 credit hours)

CE 41	Engineering Surveys (3)

Junior Year, First Semester (16-19 credit hours)

CE 101	Computer Methods (1)
CE 121	Mechanics of Fluids (3)
CE 159	Structural Analysis I (3)
CE 143	Soil Mechanics (3)
Mech 102	Dynamics (3)
	Elective (3-6)*

Junior Year, Second Semester (15-18 credit hours)

CE 110	Civil Engineering Lab (3)
CE 170	Environmental Engineering I (3)
CE 160	Structural Design (3)
CE 222	Hydraulic Engineering (3)
	GS Requirement (3)
	Elective (0-3)*

Summer

CE 100	Industrial Employment

Senior Year, First Semester (15-18 credit hours)

CE 203	Professional Development (3)
CE 207	Transportation Engineering (3)
	GS Requirement (3)
	Elective (6-9)*

Senior Year, Second Semester (15-18 credit hours)

CE 200	Engineering Planning (3)

GS Requirement (3)
Elective (9-12)*

*Please refer to description of normal program, page 52.

Elective opportunities total 18-30 credits, with at least six credits to be in engineering science courses. The engineering sciences form the transition between basic sciences and engineering design. For the civil engineering student, typical engineering science electives would be M.E. 104, 105, and 242; Mech. 203; Met. 63 or 91; E.E. 20, 160, 161, and 162.

Undergraduate Courses

11. Engineering Graphics (2) fall
Use of drawing instruments; freehand lettering and shape description; theory of orthographic projection, revolution, and pictorial representation; theoretical problems in space relationships between points, lines and planes; surfaces as loci. Emphasis on visualization and geometric logic. Mr. Dinsmore.

13. Civil Engineering Concepts (3) fall
Introduction to the analysis and design of civil engineering systems. Graphical communication and analysis. Case studies and student projects in the several areas of civil engineering specialization. Oral and written reports. Mr. Dinsmore.

40. Principles of Surveying (3) spring
Study of errors in measurements, their effect on field procedures and office computations and their use in determining precisions for methods and equipment to meet prescribed accuracies and in preparation of survey specifications. Study of methods in the use of the tape, transit, and level in land, engineering, and topographic surveying. Astronomical observations for true direction, state plane coordinate systems, survey computations, theory of errors and statistics applicable to second order, third order, and ordinary surveys. Messrs. Liebig and Slutter.

41. Engineering Surveys (3) summer
Applications of surveying to route location, topography, highways, construction, and boundaries. Daily recitation and field work for a three-week period. Prerequisite: C.E. 40. Messrs. Liebig and Slutter.

100. Summer Employment
During the summer following the junior year, students are required to spend at least eight weeks in practical work, preferably in the field which the student plans to enter after graduation. A written report on the experience obtained is due on return from summer vacation. Prerequisite: senior standing.

101. Computer Methods (1) fall
Computer programming of problems encountered in civil engineering, predicated on numerical techniques. Prerequisite: Engr. 1. Mr. Kostem.

103. Special Problems (1-6)
Supervised individual research problems with report. Prerequisite: consent of department chairman.

104. Readings in Civil Engineering (1-3)
Study of selected technical papers, with abstracts and reports. Prerequisite: consent of department chairman.

106. Structural Design (3) spring
Elementary theory and design of structures in steel, wood, and concrete. An abridged course in stress analysis and design for students other than civil engineers. Prerequisite: Mech. 11.

110. Civil Engineering Laboratory (3)
Experimental investigation of civil engineering problems. The collection, evaluation and interpretation of data. Laboratory work in the major disciplines of civil engineering concluded with an experimental investigation in one or more areas of the student's choice. Prerequisites: junior standing or consent of the department chairman.

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, with emphasis on pipe flow. Dynamic similitude and modeling of fluid flows. Prerequisite: Mech. 102 or 103 previously or concurrently. Messrs. Murray and Brune.

123. Fluid Mechanics Laboratory (1) spring
Exercises in closed conduit flow, open-channel flow, and hydraulic machinery. Prerequisite: C.E. 121 or M.E. 231.

143. Soil Mechanics (3) 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. 11 or consent of department chairman.

157. Concrete Laboratory (1) fall
Principles of the behavior of plain and reinforced concrete. Design and preparation of concrete mixtures, and tests of aggregates, control cylinders, and reinforced concrete beams. Prerequisite: C.E. 110; C.E. 160 previously or concurrently.

159. Structural Analysis I (3) fall
Elastic analysis of statically determinate frames and trusses; deflections by the method of virtual work; force method analysis of indeterminate structures; moment distribution concept. Prerequisite: Mech. 11.

160. Structural Design (3) 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: C.E. 159.

170. Environmental Engineering I (3) spring
Quantitative analysis of water sources. Analysis and design of the transmission, distribution, and collection of wastewater and storm water. Water and wastewater treatment processes. Prerequisite: C.E. 121. Messrs. Johnson and Usinowicz.

200. Engineering Planning (3) spring
Principles of systems planning of civil engineering projects. A study of factors affecting the inception, evaluation, planning, design and completion of typical engineering projects, including technical, political, economic, social and environmental factors; urban planning; plan implementation; decision making; management techniques and reporting; optimal principles. Prerequisite: senior standing. Messrs. Daniels and Dinsmore.

203. Professional Development (3) fall
Elements of professionalism and registration; responsibilities of technical and professional societies, and of the civil engineer as a professional and citizen. Principles of technical writing and law, applicable to civil engineers. Written and oral reports. Prerequisite: senior standing. Mr. Liebig.

207. Transportation Engineering I (3) fall
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: C.E. 41, senior standing. Messrs. Liebig and Slutter.

222. Hydraulic Engineering (3) spring
Hydraulic measurements, hydraulic machinery, hydraulic structures, open-channel flow, transport of sediments, coastal engineering. Prerequisite: C.E. 121 or equivalent. Messrs. Brune and Murray.

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. Slope stability and embankment design. Seepage. Prerequisite: C.E. 143 or consent of department chairman. Mr. Fang.

259. Structural Analysis II (3)
Deflection of beams and frames by moment area methods; force analysis of complex structures; plastic analysis by mechanism methods; influence coefficients; introduction to displacement methods of analysis; computer applications. Prerequisite: C.E. 159.

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: C.E. 160, C.E. 259 previously or concurrently. Mr. Tall.

263. Structural Concrete Design (3) fall
Design of reinforced concrete structural elements and basic systems, including continuous beams, frames, slabs, footings, and walls. Serviceability criteria. Introduction to prestressing and torsion. Prerequisite: C.E. 160, C.E. 259 previously or concurrently. Messrs. Daniels and VanHorn.

271. Environmental Engineering II (3) fall
Introduction to unit operations and unit processes involved in water and waste water treatment facilities. Consideration of combinations to meet water quality requirements, either as water supply source or as receiving mantle. Prerequisite: C.E. 170. Mr. Usinowicz.

280. Internship (3)
Individual opportunities for qualified advanced civil engineering students to obtain practical experience through association with civil engineers, architects and planners. Typical fields of practice include transportation, hydraulic engineering, environmental engineering, air pollution, regional and city planning, architectural planning, and public works engineering. Prerequisite: senior standing. May be repeated once for credit.

300. Apprentice Teaching in C.E. (1-3)

316. Civil Engineering Planning (3)
Project-oriented planning of one or two civil engineering projects of students' choice, with oral and written report; task force approach, collection and analysis of data; consideration of technical and environmental factors; cost analyses. Interaction with consulting engineers and planners. Prerequisite: senior standing or consent of department chairman.

322. Hydromechanics (3)
Fundamental equations of fluid flow. Stress on viscous flow with introductions to turbulence, boundary layers, and turbulent shear flow. Hydraulic applications. Prerequisites: Math. 205, C.E. 121.

323. Hydraulic Laboratory Practice (1-3)
Study of theory and methods of hydraulic experimentation.

324. (Mech. 323) Fluid Mechanics of the Ocean and Atmosphere (3)
For course description, see Mech. 323.

325. Hydrology (3) fall
Hydrologic cycle. Precipitation, evaporation, transpiration, infiltration. Ground water. Stream flow, hydrographs, floods. Statistical analysis applied to hydrology. Prerequisite: C.E. 121 or equivalent. Mr. Brune.

326. Ground Water Hydrology (3) spring
The study of subsurface water, its environment and distribution. Theory of ground water movement. Mechanics of well flow. Sea water intrusion. Artificial recharge. Basin development. Prerequisite: C.E. 121 or consent of department chairman. Mr. Murray.

328. Channel and Oceanographical Hydraulics (3) fall
Hydraulics of fixed bed channels, specific energy concept, secondary current, frictional resistance, flow stability, artificial obstruction. Oceanographical engineering and coastal hydraulics, theory of waves, wave forces, wave refraction and diffraction, coastal processes. Prerequisites: C.E. 121 and consent of department chairman. Mr. Murray.

332. Ocean Engineering (3) spring
Quantitative oceanographic information for engineers, with emphasis on the coastal zone. Navigation and energy systems; materials; pollution problems; brief survey of the offshore petroleum and mining industries; manned and telechiric undersea operations. Prerequisite: consent of department chairman. Mr. Richards.

333. Ocean Engineering Field Investigations (1-3) summer
Field studies in ocean engineering involving participation in research investigations conducted at sea. Prerequisite: consent of department chairman. Messrs. Richards and Hirst.

341. Soil Stabilization (3) spring
The mechanisms of soil stabilization: compaction, use of additives (aggregates, cement, asphalt, chemicals), special techniques. Principles and techniques of soil stabilization for use as foundation material in highways and airfields; theories of flexible and rigid pavement design. Prerequisite: C.E. 143 or equivalent. Mr. Hirst.

342. Experimental Soil Mechanics (3) fall
Experimental studies dealing with the measurement of soil properties in the laboratory and in situ; application of these properties to design; consolidation; strength of soils in triaxial compression and other shear tests, including measurement of pore water pressures; model design and analysis; field measurement of in situ soil properties; laboratory and field instrumentation. Prerequisite: C.E. 143 and senior standing. Messrs. Hirst and Fang.

343. Seepage and Earth Structures (3) spring
Long- and short-term stability of embankments and cut slopes; numerical and graphical methods of stability analysis; seepage through soils; design of earth dams, embankments and excavations; influence of seepage on embankment stability; construction control and field measurement of pore pressures and earth movements. Prerequisite: C.E. 143 or equivalent. Mr. Fang.

352. Structural Dynamics (3)
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. Prerequisite: Math. 205, C.E. 259 or equivalent. Mr. Yen.

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: C.E. 259 or equivalent.

360. Advanced Structural Design (3) spring
Project-oriented advanced design of structures for bridges and buildings in steel or reinforced concrete and combinations of both materials. Emphasis on economy, strength and performance. Consideration of design of timber or glued-laminated structures, depending on student interest. Prerequisites: C.E. 261 and C.E. 263 or equivalent.

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. Prerequisites: C.E. 263; C.E. 259 previously or concurrently, or consent of chairman. Mr. Huang.

371. Environmental Health Engineering (3) spring
Engineering applications to public health; food and milk sanitation, solid wastes, vector control, communicable disease control. Institutional and industrial sanitation, housing, air pollution, bathing and recreational water quality. Prerequisite: senior standing. Mr. Johnson.

374. Sanitary Engineering Analysis and Operations (3) fall
Applications of chemical theory, concepts of operations commonly used in water quality control and laboratory evaluations for design of processes in water and waste-water treatment. Prerequisite: C.E. 271 or consent of chairman. Mr. Usinowicz.

376. Water Resources Engineering (3) fall
Utilization of principles of hydraulics, hydrology and environmental engineering in problems of erosion and flood control, power, irrigation, navigation, and water quality control; economics and water law in river basin planning. Prerequisites: C.E. 222 and C.E. 170 or consent of department chairman. Mr. Johnson.

380. Design Projects (1-6) fall-spring
Design project work as a member of a team, probably including students from differing disciplines. The project will attack a problem which, when possible, relates to a problem of one of the local communities or industries. Specific projects will normally be guided by faculty from several departments with consultants from off-campus. May be repeated for credit. Prerequisite: consent of department chairman.

381. Special Topics (1-3)
A study of selected topics in civil engineering, not included in other formal courses.

385. Research Procedures Seminar (1) spring
Planning and execution of research projects, survey of cur-

rent research, elements of proposals and budgets. Literature search procedures. Presentation of data, and of written and oral reports. Guidelines for visual aids. Mr. Beedle.

For Graduates

Graduate studies in civil engineering permit the student to build upon the broad background of undergraduate education in order to prepare 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 study programs either encompassing a wide range of interests or pursuing a special area of civil engineering in depth. The department offers advanced work in structural engineering, geotechnical engineering, geotechnical ocean-engineering, hydraulic engineering and environmental engineering, leading to the M.S. and Ph.D. degrees.

A graduate program leading to the M.S. degree will normally consist of a number of courses in a major area plus at least two courses in a minor area or areas. Each candidate for a master's degree is expected to take at least one research course (C.E. 429, 439, 449, 469, 479, 481, or 491), but a minimum of 24 hours of the program should consist of courses outside this group. Research assistants and fellows normally will prepare a thesis.

A number of selected subjects offered by the departments of mechanical engineering and mechanics, chemical engineering, metallurgy and materials science, biology, and geological sciences may also be considered a part of the major field in civil engineering. A list of such subjects is available through the chairman of the department.

The Ph.D. degree program normally includes (1) courses in the major field, (2) courses in minor fields, and (3) a dissertation presenting results of original research. In addition, each candidate is required to have some education in one or two non-engineering fields. This requirement may be met by taking two courses (200-level or above), or by taking two foreign language courses, or by passing a language proficiency examination. Holders of master's degrees planning to become candidates for a Ph.D. must take a qualifying examination at the first opportunity following one semester in residence. After qualification, the program of work is formulated by the candidate, his or her special committee, and the department chairman.

The laboratories of the department are located in the Fritz Engineering Laboratory. Established in 1909 by the generosity of the late John Fritz, and improved through additions to apparatus and equipment, the laboratory offers complete facilities for research and instruction in structural engineering, geotechnical engineering, model analysis, fluid mechanics and hydraulics, environmental engineering, and other related fields.

Structural testing equipment includes dynamic testing machines, a 5,000,000-pound universal hydraulic testing machine, and other special loading apparatus. Hydraulic testing equipment includes a dredge pump test facility, plus installations for testing models of spillways, open channels, and beach facilities. A brochure describing the research facilities and programs is available on request.

An interdisciplinary relationship with the Center for Marine and Environmental Studies enables the development of academic and research programs in ocean engineering.

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 duties required of holders of assistantships provide valuable training which supplements the formal course offering. The graduate course offering of the department is programmed to fit the schedule of half-time assistants. A very limited number of scholarships and fellowships are available to provide financial aid for full-time study.

403. Analytical Methods in Civil Engineering (3) fall
Analytical and numerical methods used in various fields of civil engineering. Matrix algebra in engineering analysis. Iterative, differencing, and discretization techniques. Energy principles and special methods. Treatment of typical differential equations in civil engineering. Introduction to theory of elasticity with some engineering applications. Prerequisite: Math. 205 or equivalent. Mr. Ostapenko.

408. Computer Methods in Civil Engineering (3) spring, alt. yrs.
Numerical and computer-oriented methods specially applicable to the solution of complex problems arising in various fields of civil engineering. Solutions of well- and ill-conditioned linear and non-linear systems. Eigenvalue formulation of stability and dynamic problems. Reduction techniques, applied linear graph theory, integration schemes for large structural systems. Optimal design by linear programming. Introduction to problem-oriented languages and computerized design. Prerequisites: C.E. 403 or equivalent, and working knowledge of FORTRAN IV programming. Mr. Kostem.

409. Finite Element Method in Structural Mechanics (3) spring, alternate years
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: C.E. 403, C.E. 450, or equivalents; working knowledge of FORTRAN. Mr. Kostem.

424. Surface Water Hydrology (3) spring
The study of quantities in the flow of water in streams. Hydrographs. Application of statistical analysis and probability to hydrological problems. Drainage basin analysis. Prerequisite: C.E. 325 or equivalent.

425. Hydraulics of Sediment Transport (3)
Hydrodynamic forces on particles, settling velocity. Sediment transport in open channel: tractive force theory, bed load and suspension theory, total load and wash load. Bedform mechanics, cohesive channel hydraulics. Sediment transport in closed conduits. Shore processes and coastline hydraulics. Prerequisites: C.E. 121 and C.E. 222, and consent of department chairman.

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: C.E. 322 and consent of chairman. May be repeated for credit.

429. Hydraulic Research (1-6)
Individual research problems with reports. May be repeated for credit.

431. Geotechnical Ocean Engineering (3) fall, alternate years
Study of the engineering and scientific aspects of soils flooring the oceans; soils and their distribution; theory and practice of sampling, laboratory and in situ testing, geophysical methods, and computerized data synthesis; biological, geochemical, and physical properties of the electrolyte-gas-solid soil system of the sea floor and the response of this system to applied static and dynamic forces. Prerequisite: C.E. 143 or equivalent. Messrs. Richards and Hirst.

437. Advanced Topics in Geotechnical Ocean Engineering (1-3)
Advanced study of selected topics in geotechnical ocean engineering, such as: physico-chemistry of ocean sediments; foundation design in soft sediments; instrumentation for deep-sea soil surveys; and others. Selection of topics will depend on particular qualifications of the staff, as well as interest of students. Prerequisite: consent of chairman. May be repeated for credit.

439. Ocean Engineering Research (1-6)
Individual research problems with reports. May be repeated for credit.

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. Mr. Hirst.

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; slope stability; vibration and other dynamic forces. Prerequisite: C.E. 443. Messrs. Fang and Hirst.

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 foundations and piles; flexible and rigid retaining wall design; embankment design; control of seepage and other construction problems; site investigations. Prerequisite: a course in soil mechanics. Mr. Fang.

447. Advanced Topics in Geotechnical Engineering (1-3)
Advanced studies in selected subjects related to geotechnical engineering. The general areas in which studies may be taken 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 department chairman. May be repeated for credit.

449. Geotechnical Research (1-6)
Individual research problems relating to soil engineering, with report. Prerequisite: a course in soil mechanics.

450. Advanced Structural Theory I (3) fall
Introduction to force and displacement matrix analysis of structures. Consideration of influence of support settlement, temperature, and fabrication tolerances on stress resultants and deformations. Prerequisite: C.E. 259 or equivalent. Messrs. Driscoll and Daniels.

451. Advanced Structural Theory II (3) spring
Specialized methods of analysis: column analogy, moment distribution. General treatment of deformation methods using matrix algebra. Selected topics in structural theory: influence lines, multi-story building frames, space structures. Introduction to finite element method; non-linear problems. Prerequisite: C.E. 450. Mr. Driscoll.

453. Structural Members and Frames (3) fall
General torsion of thin-walled open, closed, and combined open and closed cross-sections; general instability of thin-walled members; inelastic instability; special problems in stability. Desirable preparation: Mech. 415. Prerequisites: C.E. 403 and consent of department chairman. Mr. Lu.

454. Plate and Shell Structures (3) spring, alternate years
Plates and slabs loaded transversely and in their plane. Buckling and post-buckling behavior of elastic and inelastic plates. Membrane and bending analysis of cylindrical, rotational, and hyperbolic-paraboloidal shells. Emphasis on engineering methods. Design considerations. Prerequisites: C.E. 403, consent of department chairman. Mr. Ostapenko.

455. Advanced Structural Dynamics (3)
Analysis and design of structures to resist wind, earthquake, and blast loading. Matrix methods and computer applications. Non-linear and elasto-plastic response. Damping characteristics of structures and structural components, spectral analysis, dynamic instability. Characteristics of aerodynamic and seismic forces and nuclear blast. Introduction to vibration of three-dimensional structural systems. Prerequisites: C.E. 403, C.E. 352 or Mech. 406, and C.E. 450 or equivalent.

457. Theory and Design of Steel Structures (3) spring
Analysis and design of steel structures; structural connec-

tions; 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. Mr. Fisher.

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: C.E. 359. Mr. Chen.

462. Experimental Methods of Structural Analysis (3)
Mechanical properties of structural materials and different procedures of evaluating these properties; experimental methods of stress analysis; statistical analysis of experimental data.

463. Experimental Methods of Structural Research (3)
Mechanical properties of structural materials and different procedures of evaluating these properties; experimental methods of stress analysis; statistical analysis of experimental data.

464. (Mech. 416) Theory of Plates and Shells (3)
For course description see Mech. 416.

465. Advanced Topics in Concrete Structures (3) fall
Advanced topics in reinforced and prestressed concrete. Limit design concepts. Yield line theory for concrete slabs. Composite members. Additional topics may include design of concrete bridge systems, shear walls, arches; seismic design. Prerequisite: C.E. 263 or equivalent. Mr. Huang.

466. Concrete Shell Structures (3) spring, alternate years
Analysis and design of concrete shell structures. Folded plates, cylindrical shells, and shells of double curvature. Typical practical problems. Prerequisites: C.E. 403, consent of department chairman. Mr. Ostapenko.

467. Advanced Topics in Structural Engineering (1-3)
Advanced study of selected topics in structural mechanics and engineering, such as: finite element methods, suspension systems; space frames; stability of non-linear systems; cold-formed and lightweight construction; optimization and reliability; second-order phenomena in structures; interaction of structures with 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 department chairman. May be repeated for credit.

468. (Mech. 415) Stability of Elastic Structures (3)
For course description see Mech. 415.

469. Structural Research (1-6)
Individual research problems with reports. May be repeated for credit.

471. Water Treatment Facilities (3) fall
Theory and design of water treatment facility components, from source to distribution system. Laboratory work in water chemical parameter determinations for design applications. Prerequisite: C.E. 374. Mr. Johnson.

472. Water Pollution Control Facilities (3) spring
Fundamental principles and design of water pollution control facilities for domestic and industrial waste waters. Physical-chemical and biological studies in laboratory determination of design parameters to be applied in design procedures. Prerequisite: C.E. 374. Mr. Johnson.

475. Advanced Topics in Water Resources (1-3)
Advanced study of selected topics in areas such as: physico-chemical methods of water quality control; biological systems for waste-water treatment; multiple use of water resources; and others. Selection of topics will depend on particular qualifications of the faculty as well as interest of the students. Prerequisite: consent of the department chairman. May be repeated for credit.

479. Environmental Engineering Research (1-6)
Individual research problems in environmental engineering with summary report. May be repeated for credit.

481. Special Problems (1-6)
An intensive study, with report, of some special field of civil engineering which is not covered in the other courses. A design project or an interdisciplinary study of some problem related to civil engineering may also be included. May be repeated for credit.

483. Graduate Seminar (1-3)
Study of current topics in the field of civil engineering.

491. Thesis (1-6)

Classics

Professors

Joseph Abele Maurer, Ph.D., *Chairman*
Douglas David Feaver, Ph.D.

Associate Professor

Edna Sophia deAngeli, Ph.D.

Majors in Classics seek, through insight into the culture of ancient Greece and Rome, to gain an appreciation of Greco-Roman achievements in art, literature, philosophy, and science, and to formulate an evaluation of the importance of these for modern culture. Readings in the original languages of masterpieces, chosen both for their usefulness in developing skill in the languages and for their intrinsic worth and abiding importance, aim at developing an accumulative growth in the mastery of the languages and in the ability to interpret, criticize, and evaluate the achievements of classical civilization.

The basic work is supplemented by studies in the history, archaeology, art, philosophy, and literary history of Greece and Rome, and by an introduction to the basic tools and disciplines of scholarly research in this area. Students are encouraged to undertake research in fields of their own interest.

Classics as a major has stood the test of time, offering a general cultural background for careers in widely diverse fields in the professions, business, and public service. It has particular relevance as a preparation for careers in teaching, law, writing, archaeology, and the church.

Lehigh University is a cooperating institution of The American School of Classical Studies at Athens. Graduates of Lehigh University receive free tuition in the school.

Major in Greek

Required Preliminary Courses

Gk 1, 2	Elementary Greek (6)
Gk 3, 4	Intermediate Greek (6)

Required Major Courses

Gk 111, 112	Greek Drama (6)
Gk 113	Greek Historians (3)
Gk 203	Greek Epic (3)
Gk 271	Readings (3)
Gk 316	Plato (3)
Gk 21	Ancient History (3)
Gk 50	Greek Literature in English Translation (3)
Gk 202	Greek Archaeology (3)

Majors in Greek write a translation examination during their seventh semester. No comprehensive examination is required.

Major in Latin

Required Preliminary Courses

Lat 61	Elementary Latin (3)
Lat 62	Caesar (3)
Lat 63	Nepos and Cicero (3)
Lat 65	Vergil (3)

Required Major Courses

Lat 166	The Latin Lyric (3)
Lat 168	Latin Drama (3)
Lat 22	Ancient History (3)
Lat 51	Latin Literature in English Translation (3)
Lat 203	Archaeology of Italy (3)
	and twelve hours from the following:
Lat 211	Readings (3)
Lat 212	Readings (3)
Lat 303	The Roman Epic (3)
Lat 304	Latin Historical Grammar (3)
Lat 305	Satire (3)
Lat 306	Roman Prose Writers (3)

Majors in Latin write a translation examination during their seventh semester. No comprehensive examination is required.

Major in Classics

This major is designed for those planning to go on to graduate work in classics, ancient history, ancient philosophy, classical archaeology, and classical linguistics.

Programs in this major will be worked out for each student with due consideration for the individual's particular preparation and specific goals. In general the program will require as a minimum:

(a) 18 hours of courses in either the Latin or Greek language at the "100" level or higher.

(b) 12 hours of courses in the second language.

(c) 6 hours in ancient history (Greek 21, Latin 22).

(d) 6 hours in Senior Seminars (Greek 381, Latin 381).

Depending upon specific goals the student will be strongly urged to take courses in fine arts, mediaeval history, philosophy, French and German.

Either a comprehensive examination or a senior essay will be required for graduation.

Major in Classical Civilization

Required preliminary courses (9 credit hours)

One course in Latin or in Greek at the 100 level	(3)
Gk 21	Ancient History (3)
Lat 22	Ancient History (3)

Required major courses: (24 credit hours in one of the areas of concentration)

Concentration in Archaeology

Gk 102	Ancient Art (3)
Gk 201	Archaeology of the Near East (3)
Gk 202	Archaeology of Greece (3)
Lat 203	Archaeology of Italy (3)

Lat 204	The Ancient City (3)
S.R. 9	The Anthropological Enterprise (3)

One course chosen from the area of classical literature (3)

One course chosen from the following: Phil. 131; R.S. 111, 112, or 113 (3)

Concentration in Classical Literature

Gk 50	Greek Literature in English Translation (3)
Lat 51	Latin Literature in English Translation (3)
Gk 102	Ancient Art (3)
Gk 251	Classical Mythology (3)
Gk 203	Greek Epic (3) or
Lat 303	The Roman Epic (3)

One approved course in English Literature or Modern Foreign Literature in Translation at the appropriate level. Advanced courses in Greek, Latin or modern foreign languages may be offered to meet this requirement, e.g.:

Engl 323	Shakespeare and the Elizabethan Drama (3)
Engl 331	Milton (3)
Drama 301	History of the Theatre (3)
Fr 321	French Literature in Translation (3)

One course chosen from the area of Archaeology (3)

One course chosen from the following: Phil. 131; R.S. 111, 112, or 113 (3)

A comprehensive examination is required in the area of concentration.

Greek

Undergraduate Courses

1. Elementary Greek (3) PU fall
For all students who desire to obtain a knowledge of the fundamentals of the Greek language. Early in the semester there will be reading in stories and legends in easy Greek.

2. Elementary Greek (3) PU spring
Continued work in Greek vocabulary, forms, and syntax. Selected readings in Greek prose. Prerequisite: Gk. 1.

3. Intermediate Greek (3) PU fall
Xenophon: *Anabasis,* and other works. Grammar review. Prerequisites: Gk. 1 and 2, or one year of entrance Greek.

4. Intermediate Greek (3) PU spring
Plato: *Euthyphro, Apology,* and *Crito,* or other dialogues. Prerequisite: Gk. 3.

21. (Hist. 21) Ancient History (3) PU 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. Mr. Maurer.

50. Greek Literature in English Translation (3) PU fall
The development of the major departments of Greek literature; required readings in English translations, with special attention to the epic, drama, and lyric poetry. No knowledge of the Greek language is required. Mrs. deAngeli.

102. (F.A. 102) Ancient Art (3)
For course description, see Fine Arts.

111. Greek Drama (3) fall, alternate years
Representative plays of Sophocles, Euripides, and Aristophanes. Literary study of the drama. Prerequisite: Gk. 4.

112. Greek Drama (3) spring, alternate years
Continuation of Gk. 111. Prerequisite: Gk. 4.

113. Greek Historians (3) fall, alternate years
Selections from Herodotus, Thucydides, or Xenophon. A study of Greek historiography. Prerequisite: Gk. 4.

For Advanced Undergraduates and Graduates

201. Archaeology of the Near East (3) PU fall, alt. yrs.
Aims and methods of archaeology. A chronological survey of archaeological finds from Palaeolithic, Neolithic, Bronze Age, Iron Age and later cultures in the Near East, concentrating on the Nile, Tigris-Euphrates River basins, and the Levant. Material illustrating the cultures and events of the Bible. Mr. Feaver.

202. Greek Archaeology (3) PU fall, alternate years
Aims and methods. A chronological presentation of prehistoric civilizations including the Neolithic, Minoan, Helladic, and Mycenaean periods. A study of extant ancient monuments, buildings, and city plans of important sites of the classical and Hellenistic periods. Lectures, collateral readings, and reports. Mr. Feaver.

203. Greek Epic (3)
Reading of considerable portions of the Homeric Epics and a study of the poems as works of literature. Studies of the background of the poems, and introduction to scholarly problems of interpretation and theories of origins. Prerequisites: six hours of courses at the 100 level and consent of department chairman.

251. Classical Mythology (3)
Readings in the major myths and legends of ancient Greece and Rome, with intensive study of those having the greatest relevance for modern man. The changing aspects of myth as reflected in both ancient and modern literature. Consideration of the transmission of myth in non-literary aspects of our culture. Mrs. deAngeli.

271. Readings (3) spring, alternate years
Intensive reading in one author or in a selected genre. Prerequisites: six hours of courses at the 100 level and consent of chairman.

316. Plato (3)
The Republic, and other dialogues. Lectures on classical philosophy. Prerequisites: six hours of courses at the 100 level and

consent of department chairman.

381. Senior Seminar (3)
A proseminar: introduction to classical scholarship with particular attention to the methods of research, bibliographical aids, and scholarly literature. Surveys will be made of such varied fields as archaeology, numismatics, hermeneutics, palaeography, and epigraphy. Prerequisite: consent of department chairman.

Latin

22. (Hist. 22) Ancient History (3) PU spring
Continuation of Gk. 21. The Hellenistic Age. Rome from its origin to 395 A.D. Mr. Maurer.

51. Latin Literature in English Translation (3) PU spring
A study of Latin literature by means of the best English translations. The lives of the most important authors are studied and their works read according to the major departments of literature—history, comedy, epic, lyric, etc. Emphasis is placed on the chronological development of the literature and historical background necessary to the interpretation of the author's works. Lectures and readings with special reports. No knowledge of the Latin language is required. Mrs. deAngeli.

61. Elementary Latin (3) PU fall
For all students who desire to obtain a knowledge of the fundamentals of the Latin language. Special emphasis on English derivations and the principles of grammar.

62. Caesar (3) PU fall
Selections from Caesar: *The Gallic War*. Prose composition and syntax. Prerequisite: Lat. 61 or two entrance units.

63. Nepos and Cicero (3) PU fall
Nepos: *de Viris Illustribus;* Cicero's orations and either *de Senectute* or *de Amicitia*. Prerequisite: Lat. 62 or three entrance units.

65. Vergil (3) PU spring
Vergil: *Aeneid,* selections from the entire work; study of the aesthetic, political, and philosophical values of Vergil's poetry. Prerequisite: Lat. 63 or at least three entrance units.

166. The Roman Lyric (3) fall
Selected poems of Catullus. Lectures on the history and development of lyric poetry; constant practice in reading the more important meters; memorization of stanzas and passages. Prerequisite: Lat. 65 or at least four entrance units.

168. Latin Drama (3) spring
Readings of selected plays of Plautus, Terence, and Seneca. Prerequisite: Lat. 65 or at least four entrance units.

For Advanced Undergraduates and Graduates

203. Archaeology of Italy (3) PU spring, alternate years
Neolithic, Terramara, Villanovan, and Etruscan cultures. Rome the city: its buildings, monuments, and streets, its destruction and rediscovery through excavation; origin and growth of the city; the three periods, empire, republic, and kingdom; methods of identifying and dating monuments. A survey of Pompeii, Herculaneum, and Ostia. Lectures, readings and reports. Mr. Feaver.

204. The Ancient City (3) PU spring, alternate years
Ancient cities seen through concepts of human community and political theory as compared with archaeological findings; 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. Mr. Feaver.

211. Readings (3) fall
Intensive readings in one author or in a selected genre. Prerequisites: six hours of courses at the 100 level and consent of department chairman.

212. Readings (3) spring
Intensive reading in one author or in a selected genre. Prerequisites: six hours of courses at the 100 level and consent of department chairman.

303. The Roman Epic (3)
The epic in Latin literature with lectures on the Greek models; early Latin translations of Greek epics: later minor writers of epic. Passages from Lucretius, Vergil, and Ovid; a study of the *Aeneid* in its entirety. Prerequisites: six hours of courses at the 100 level and consent of department chairman.

304. Latin Historical Grammar (3)
The development of Latin syntax with survey of early Latin. Syntactical analysis of Caesar, Cicero, and Vergil. The development of classical prosody and metrics with emphasis on changes in the hexameter from Catullus and Lucretius to Vergil. The course is designed primarily for teachers of Latin in secondary schools and for majors in Classics planning to teach. Prerequisites: six hours of courses at the 100 level and consent of department chairman.

305. Satire (3)
Selected satires of Horace and Juvenal. Lectures on the history of Roman satire and its influence on modern literature; study of social conditions under the empire. Prerequisites: six hours of courses at 100 level and consent of department chairman.

306. Roman Prose Writers (3)
Selections from Cicero, Tacitus, and Seneca. Prerequisites: six hours of courses at 100 level and consent of department chairman.

382. Senior Seminar (3)
Continuation of Gk. 381. Prerequisite: consent of department chairman.

Economics

Professors

Finn Bjorn Jensen, Ph.D., *MacFarlane Professor and Chairman*
Jay Richard Aronson, Ph.D.
Nicholas W. Balabkins, Ph.D.
Alvin Cohen, Ph.D.
Gerald Garb, Ph.D.
Eli Schwartz, Ph.D.
L. Reed Tripp, Ph.D., *Magee Professor*

Associate Professors

Jon Terence Innes, Ph.D.
Warren Aiken Pillsbury, Ph.D.
Ching Sheng Shen, Ph.D.
Robert J. Thornton, Ph.D.
John E. Walker, Ph.D.

Assistant Professors

John Daniel Keefe, M.A.
Robert J. Thornton, Ph.D.
R. Allen Moran, Ph.D.
John R. McNamara, Ph.D.

Major in Arts and Science

Note: Economics 1 is a prerequisite for all courses in economics.

Required Preliminary Courses for B.A.

Freshman Year

Eco 1	Economics (4)
Math 41 and 44	BMSS Calculus (6)

Required Major Courses

Sophomore Year

Eco 45	Statistical Method (3)
Eco 129	Money & Banking (3)

Junior Year

Eco 206	Microeconomic Analysis (3)
Eco 219	Macroeconomic Analysis (3)
Eco or Fin	Any 300-level course (6)

Senior Year

Eco or Fin	Any 300-level course (6)

Major in College of Business and Economics

Economics Major

Required: 15 credits of economics beyond the core listed on page 47.

Undergraduate Courses

1. Economics (4) fall-spring
A 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.

45. Statistical Method (3) fall-spring
Descriptive statistics, elementary probability and probability distributions, sampling, estimation of population parameters, decision theory, regression and correlation, analysis of variance, non-parametric tests, time series analysis, and index numbers. Prerequisites: Math. 41 or equivalent.

129. Money and Banking (3) fall-spring
A general course dealing with the nature and functions of money and commercial banking, monetary and banking development in the United States, the value of money, and monetary, credit and fiscal policies.

For Advanced Undergraduates and Graduates

All of the following courses in economics have as a prerequisite Economics 1 or equivalent.

206. Microeconomic Analysis (3) fall-spring
Determination of prices in terms of the equilibrium of the business enterprise and consumer choices in markets of varying degrees of competition; determination of wages, rent, interest, and profits.

219. Macroeconomic Analysis (3) fall-spring
An introduction to macroeconomic measurement, theory, and policy. Provides framework within which broad macroeconomic policy prescription can be formulated especially with reference to such problems as inflation and unemployment.

300. Apprentice Teaching in Economics (1-3)

303. Economic Development (3) fall 1975 and every other year
The principal determinants of economic development; economic development in advanced and underdeveloped countries. Mr. Cohen.

305. The Economic Development of Latin America (3) spring 1976 and every other year
Forces at work in the changing economics in Latin America: in addition to the economic variables, social and political factors are considered and related to technological change and the development process. Mr. Cohen.

309. Comparative Economic Systems (3) fall
A comprehensive examination of the philosophical, economic, and political tenets of American Capitalism, Soviet Socialism, and Nazi Fascism. Analysis of economic planning under various socio-economic systems: study of comparable economic growth of the U.S. and the Soviet Union. Mr. Balabkins.

310. Economic Evolution (3) spring 1977 and every other year
Long-term economic growth and social transformation of the United States. Messrs. Balabkins and Thornton.

311. Environmental Economics (3) fall-spring
Economic policies for environmental protection. The optimal development of natural resources. The relationship between economic growth and environmental degradation. Case studies in water-quality management. Mr. McNamara.

312. Urban Economics (3) spring
A survey and analysis of economic problems related to urban areas; the nature and function of cities; the economic and spatial characteristics of urban activity including housing, land value, land use, transportation, fiscal problems, urban labor markets and poverty. Mr. Pillsbury.

313. History of Economic Thought (3) fall 1976 and every other year
Chronological survey and critical evaluation of the evolution of economic science. Analysis of the contributions of the Classical, Marginalist, Neo-classical, Keynesian, Institutionalist, and Structuralist schools. Mr. Cohen.

320. Advanced Macroeconomic Analysis (3) spring 1976 and every other year
A further course in macroeconomic theory and policy. Primary consideration is given to alternative theoretical specifications of complete monetary economies and the resulting policy implications for achieving economic growth and stability. Prerequisite: Eco. 219 or equivalent. Mr. Innes.

332. Monetary-Fiscal Policy (3) spring
A course devoted to the study of 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. Current problems will receive special emphasis. Prerequisite: Eco. 219 or equivalent. Mr. Innes.

333. Managerial Economics (3) fall-spring
The fundamental business disciplines are integrated through the development of a model of managerial decision-making. Emphasis on the application of economic theory to a variety of business problems. Consideration is given to problems involving risk and uncertainty. Case studies are employed as illustrative examples.

335. Labor Economics (3) fall-spring
The structure of the labor force; the theory of wages and employment; the economics of legal and social aspects of the labor market. Messrs. Tripp and Thornton.

336. Business and Government (3) fall 1975 and every other year
Microeconomic theory and the American legal system. Efforts by the state to maintain, moderate, and supercede competitive private contracting as a social arrangement by which to promote risk-taking, efficiency, equitable exchange, progressiveness, conservation, and individual liberty. Economic analysis of results. Mr. Pillsbury.

337. Transportation and Spatial Economics (3) spring 1976 and every other year
The principles of transportation in theory and practice are integrated with traditional and spatial economics. Transport models and location theories are reviewed for varying conditions of spatial separation of economic activity. Transportation policies are analyzed and evaluated in terms of their efficiency in the allocation of resources for the firm and the economy at the local, regional and national levels. Prerequisite: Eco. 206 or consent of chairman. Mr. Pillsbury.

338. Labor Market Institutions (3) fall
The development of the social and legal status of trade unions; the process of collective bargaining; the evolution of modern social welfare programs. Messrs. Tripp and Thornton.

339. International Trade (3) fall
The theory of international trade; the theory of tariffs; United States commercial policies; the impact of growth and development on the world economy. Mr. Jensen.

340. (Fin. 340) International Finance (3) spring
The balance of payments and the theory of disturbances and adjustment in the international economy; international monetary policies. Mr. Jensen.

343. European Economic Integration (3) spring 1977 and every other year
Analysis of the problems of economic integration with special emphasis on the development of economic cooperation and integration in Western Europe. The methods and the problems of economic planning in the Common Market. United States trade and investments and European economic integration. Mr. Jensen.

346. Business Cycles and Forecasting (3) fall 1975 and every other year
A study of economic conditions, involving short-term fluctuations, growth, forecasting and stabilization proposals. Prerequisite: a course in statistics. Mr. Moran.

348. Advanced Business Cycles (3)
Recent business cycle theories; the evolution of the theories and the problems of economic change which the theories attempt to explain. Prerequisite: Eco. 346. Students desiring this course should see the department chairman.

351. Introduction to Mathematical Economics (3) fall 1976 and every other year
Applies mathematical techniques to economic problems of optimization and constrained optimization and to economic models involving both comparative static and dynamic analysis. Prerequisites: Math. 41 and 49, Eco. 206 and 219. Mr. Innes.

352. Advanced Statistical Methods (3) spring
A further course in quantitative method: sampling design, probability distributions including the analysis of variance, and multiple correlation and their application to common situations. Prerequisite: Eco. 45 or equivalent. Mr. Shen.

353. (Fin. 353) Public Finance: Federal (3) fall
A course dealing with government expenditures and revenues, the economics of taxation, and government administration. Mr. Aronson.

354. (Fin. 354) Public Finance: State and Local (3) spring 1977 and every other year
The major issues regarding revenues, expenditures, debit and budgeting policy will be examined in the light of fiscal principles and economic effects. Particular attention will be given to current practices in Pennsylvania and contiguous states. Prerequisite: Eco. 353. Mr. Aronson.

355. Empirical Economic Analysis (3)
The course provides empirical content to the theoretical concepts developed in intermediate economic theory (micro- and macro-). Prerequisites: Eco. 45, 206, and 219. Students desiring this course should see the department chairman. Mr. Innes.

371. Readings in Economics (3)
Readings in various fields of economics, designed for the student who has a special interest in some field of economics not covered by the regularly rostered courses. Prerequisite: preparation in economics acceptable to the department chairman.

372. Readings in Economics (3)
Continuation of Eco. 371.

For Graduates

404. Development Theory and Problems (3) fall 1976 and every other year
The evolution of growth doctrines and the analysis of such developmental problems as: structural versus monetary reform, ideological controversy of the appropriate economic system, balanced investment programs as opposed to unbalanced plans, the nature and changes in the aggregate production function, and dependence upon domestic as opposed to foreign sources of savings. Prerequisite: Eco. 303. Mr. Cohen.

407. History of Economic Thought (3) spring 1977 and every other year
Consideration of selected topics in the history of economic thought, with special attention devoted to tracing the origins of modern economic theory. Prerequisite: graduate exposure to economic theory. Mr. Cohen.

411. Economics of Environmental Management (3) fall 1976 and every other year
The economic theory of natural resources. Optimal policies for the development of renewable and non-renewable resources. Pollution, congestion and common property problems. Environmental quality management systems. Prerequisite: Economics 206 or equivalent and Math 44 or equivalent. Mr. McNamara.

415. (Fin. 415) Capital and Interest Theory (3) fall
See Fin. 415 for course description. Mr. Schwartz.

425. Public Finance (3) spring 1976 and every other year
Major issues in taxation of income consumption, and capital; principles of government debt management; budgeting and fiscal planning for economic stability and growth. Mr. Aronson.

431. Managerial Economics (3) fall-spring
Problems of business enterprise: price and output determination analysis of cost and demand functions in markets of various types and under various conditions of general business. Emphasis will be on the application of economic theory to business practice. Prerequisite: Eco. 206 or consent of the department chairman. Mr. McNamara.

432. Advanced Microeconomic Analysis (3) fall
A survey of methods of decision-making at the microeconomic level utilizing concepts developed in price theory and econometrics. Prerequisite: Eco. 206 or equivalent. Mr. Garb.

435. Advanced Topics in Microeconomics (3) spring 1977 and every other year
Topics in resource allocation and price determination. Theories of choice of consumers, firms, and resource owners under monopoly, monopsony, competition, and alternative market forms. Prerequisite: Eco. 432 or equivalent and consent of chairman. Mr. Garb.

436. Advanced Topics in Macroeconomics (3) spring 1977 and every other year
Theory of employment, income, and growth. Role of money in theory of output. Policies for economic stability and growth. Prerequisite: consent of chairman. Mr. Innes.

437. Labor Economics (3) fall
The economic environment of labor and industrial relations with some emphasis on current research involving theoretical and empirical analyses of labor markets. Prerequisite: Eco. 335 or Eco. 338 or equivalent. Messrs. Tripp and Thornton.

438. Labor-Management Administration (3) spring
A study of the administration of the relationship between management and the labor force both where that relationship is governed by a formal agreement and where it is not. The

concepts underlying the substantive provisions of labor agreements are analyzed. The problem of agreement-making and the methods for peacekeeping are subjected to critical appraisal. Prerequisite: Eco. 335 or 338 or equivalent. Mr. Tripp.

440. Regional Science-Metropolitan Analysis (3) fall 1976 and every other year
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. Mr. Pillsbury.

442. (Fin. 442) Foreign Trade Management (3) spring 1977 and every other year
Current problems of foreign operations, including channels of export in foreign markets, export and import financing, foreign investments, policies of government and international agencies as they affect foreign operations. Mr. Jensen.

444. (Fin. 444) Banking and Monetary Policy (3) fall-spring
Description and analysis of the U.S. monetary and banking structure. The supply and demand for funds. Financial markets. Central bank controls; monetary theory and policy. Prerequisite: a course in money and banking. Messrs. Aronson, Innes and Schwartz.

445. International Economic Theory (3)
The theory of international economics, with emphasis on the way in which general economic theory is applied to the problems and issues of international economics. Prerequisite: consent of the department chairman. Students desiring this course should see the chairman. Mr. Garb.

453. Index Numbers and Time Series Analysis (3)
Theory and construction of Index Numbers. Measurement and analysis of irregular, seasonal, cyclical and secular components. Exponential smoothing, distributed lags, and introduction to spectral analysis. Students desiring this course should see the department chairman. Mr. Shen.

454. Forecasting (3) spring 1976 and every other year
A study of the methods of business forecasting and its relation to planning with emphasis on the prediction of growth and short-term movements. Prerequisite: Eco. 346 or equivalent. Mr. Shen.

455. Econometric Methods (3) spring 1977 and every other year
Mathematical and statistical specification of economic models. Statistical estimation and test of economic parameters in single and multiple equation models. Prediction and test of structural changes. Prerequisites: background in statistics and calculus. Mr. Shen.

456. Mathematical Economics (3) fall 1975 and every other year
Designed to provide an understanding of the way in which various mathematical techniques are applied in the formulation and development of economic concepts and theories. The course may draw on theories of the consumer and of the firm, the analysis of economic fluctuations and growth, general equilibrium theory, and other areas of economics where mathematical techniques have been found to be useful. Prerequisite: consent of chairman. Mr. Garb.

461. Methodology in Theory and Research
Foundations of theory construction and empirical research in economics and related subject matter. Theory, hypothesis formation and empirical study in the business firm, organizations, industrial relations, and micro-macro research. Students desiring this course should see the department chairman. Mr. Garb.

471. Special Topics (3)
An extended study of an approved topic in the field of economics.

472. Special Topics (3)
Selected topics not covered in scheduled courses in the department. May be repeated for credit with the consent of department chairman.

490. Thesis in Economics (6)
Subjects for these may be selected by consultation with major advisor and approval of department chairman and M.A. committee.

Education

Professors

John A. Stoops, Ed.D., *Dean*
Margaret G. Hein, Ph.D., *Associate Dean*
Glenn J. Christensen, Ph.D., *University Distinguished Professor*
Alfred J. Castaldi, Ed.D.
Andrew J. Edmiston, Ph.D.
Charles W. Guditus, Ed.D.
John A. Mierzwa, Ed.D.
Paul VanReed Miller, Ph.D.
Norman H. Sam, Ed.D.

Associate Professors

Matthew W. Gaffney, Ed.D.
Margaret C. Grandovic, Ed.D.
Jerome T. Kapes, Ph.D.

Edwin B. Keim, Ed. D.
Joseph P. Kender, Ed.D.
Robert L. Leight, Ed.D.
Estoy Reddin, Ed.D.
Alice D. Rinehart, Ed.D.
William B. Stafford, Ed.D.
Elvin G. Warfel, Ed.D.

Assistant Professors

Frederick Baus, III, Ed.D., *Assistant Dean*
Raymond Bell, Ed.D.
Thomas Fleck, Jr., Ed.D.
Warren R. Heydenberk, Ed.D.
James G. Lutz, Ed.D.
David March, Ed.D.
Stephen L. Nichols, Ph.D.
Artis J. Palmo, Ed.D.
Dennis A. Pickering, Ed.D.
Doyle K. Stewart, M.S.
Stephen M. Stillman, Ph.D.
LeRoy J. Tuscher, Ph.D.
Nan Van Gieson, Ed.D.

Adjunct Professors

Mary A. Conahan, Ed.D.
Nancy Larrick, Ed.D.
Margaret Melchior Seylar, M.A.

Instructors

William J. Kirk, M.Ed.
Thomas J. Laffey, M.S.S.
Thelma P. Lifland, M.Ed.
Harry Price, M.Ed.
Mildred Sanders, M.Ed.

Lecturers

Anne E. Beidler, Ed.D.
Alexander L. Crosby, B.A.
Warren M. Davis, Ph.D.
Joseph M. Fink, M.A.
Eugene M. Hutchinson, M.Ed.
Paul Johnson, M.A.
G. A. Mellander, Ph.D.
William W. Oswalt, Ed.D.
Henry W. Ray, Ed.D.
Richard C. Richardson, Ph.D.
Stephen A. Schafer, Ed.D.
Hilary B. Shuard, M.Sc.
John C. Turoczi, Ed.D.
Dale Tyson, Ed.D.
Robert E. Wisser, Ed.D.

Centennial School Teachers

George W. Conner, Jr., B.A.
Edward J. Crawford, M.Ed.
Frederic L. Evans, M.Ed.
Jane T. Fisher, B.A.
James J. Garrigan, M.A.
Audrey L. Gilmartin, B.S.
Frances M. Jennings, A.B.
Frank J. Kidder, III, M.Ed.
Carol J. Kinney, B.A.
Mary R. Kleinginna, M.S.Ed.
Charles A. Lange, M.Ed.
Francis J. Minotto, M.S.
Lloyd C. Parker, M.Ed.
Ruth B. Parr, M.Ed.
Ray M. Scarpantonio, B.A.
June P. Schiff, M.Ed.
Barbara E. Seiffert, M.S.
Nicolette Stasko, B.A.
Karol Strelecki, M.S.
Joseph Strickland, M.Ed.
Harry O. Tachovsky, M.Ed.
Gregory A. Zebrowski, B.S.

For Advanced Undergraduates and Graduates

211. Vocational Technical Education (3)
Historical and philosophical foundations. Characteristics of vocational-technical schools and curricula. Role of school and teacher in career development. Problems of vocational choice. Relations with trades, industries, and labor organization. Cooperative programs. Prerequisite: consent of program director. Mr. Stewart.

221. Procedures in Trade and Industrial Education (3)
Teaching techniques for trade and industrial subjects. Curriculum and evaluation as related to classroom methods. Student demonstration and micro-teaching. Concurrent with Educ. 321, Classroom Practice. Prerequisite: consent of program director. Mr. Stewart.

311. Origins of Western Schools (3-6)
A study and travel seminar for experienced teachers. Emphasis is upon the nature and methods of Hellenistic and medieval schools. Relevant traditions in language, art, and philosophy are considered. Influences on American institutions are shown. Undertaken in cooperation with selected European universities. Summer session. Prerequisite: consent of the dean of the School of Education.

313. Arts and Crafts for the Handicapped (3)
Study of various artistic media (arts, crafts, music, puppetry, dramatics) which are helpful in promoting development of handicapped individuals.

315. Teaching the Emotionally and Socially Maladjusted (3)
The nature and causes of emotional and social maladjustment; methods of gaining insight into and modification of behavior; appropriate curriculum, methods, materials, and available resources. Field observations required. Prerequisite: admission to the special education program or consent of the program director. Mr. Nichols.

316. Motor Development of Handicapped Children (3)
Methods of promoting sequential motor skills in handicapped

children. Prerequisite: consent of the program director.

317. Teaching the Mentally Retarded (3)
Special needs of and vocational possibilities for retarded individuals; current educational practices, curriculum methods of teaching; materials for promoting maximal social competency; available resources. Field observations. Prerequisite: admission to the special education program or consent of the program director.

318. Language and Social Development of Handicapped Children (3)
Methods of promoting sequential language and social skills in handicapped children. Prerequisite: consent of the program director.

319. Career Education for the Handicapped (3)
Promoting attitudes, work habits, and skills which enhance employability of the handicapped; appraisal of methods for matching individuals to jobs; job market for the handicapped; various curricular and administrative designs. Prerequisite: admission to the special education program or consent of the program director.

320. Criterion-based Evaluation in Career Education (3)
Development and critical examination of criterion-based instruments for assessing students' abilities. Designed to develop skills in construction and implementation of criterion-based instruments for assessing performance in various phases of career education. Prerequisite: consent of program director.

321. 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 discussions, and observations. Prerequisite: consent of dean of School of Education.

323. Intern Seminar (3)
For undergraduate students admitted to certification programs in career education only. For details, see Educ. 429.

325. Intern Teaching (3-6)
For undergraduate students admitted to certification programs in career education only. For details, see Educ. 428.

327. Occupational and Manpower Program Development (3)
Methods and standards used in study of manpower needs and competency requirements. Interdependence of technologies, trades, and professions. School and teacher responses to change in business and industry. Labor organizations. Types of manpower development programs and methods of development. Prerequisite: consent of program director. Mr. Sam.

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.

331. Shop and Laboratory Management (3)
Systems and procedures for layout, organization, maintenance, inventory, and safety of school shops and laboratories. Issues in utilization and specialization. Instructional methods. Relationship of shop practices to curricular objectives and career standards. Prerequisite: consent of program director. Mr. Stewart.

333. Special Topics in Secondary Education (3)
Examination of an area of secondary education that is of special interest to students and faculty. May be repeated for credit. Prerequisite: consent of program director.

341. The Teacher in Social Restoration (3-6)
The functions of the teacher and the school in prevention and remediation of anti-social behavior. Field work in remedial teaching and experience in social restoration institutions. For social restoration interns only. Mr. Bell.

343. The Disadvantaged Student (3)
Philosophical analyses of disadvantagement and relevant educational theories. Applications and evaluations of special methods and techniques. For teaching interns only. Mr. Bell.

351. Statistical Methods in Research (3) fall-spring
Methods of describing and condensing sample date and drawing inferences about population characteristics. No background in statistics is presumed. Emphasis on concepts.

353. Reporting Professional Research (3)
Intensive study of and practice in the application of the principles of written exposition to common forms of professional reporting.

361. Curriculum Construction for Career Education (3)
Identification and clarification of goals and competencies. Methods of curriculum organization. Development of curriculum resources. Providing for individual differences. Organizing special experiences. Development of cooperative programs. Evaluating, recording, and reporting student progress. Prerequisite: consent of program director. Mr. Kapes.

381. Educational Systems and Information Processing (3) fall-spring
Introduction to the basic principles of systems analysis, information processing, cost analysis, and conversion systems. Emphasis to be placed upon the application of computers and data processing to administration and instruction in basic educational institutions. Mr. Tuscher.

383. Computer Assisted Instruction (3)
The design and development of computer assisted instructional units. Students design, program, and test computer-assisted instructional units in one of several modes such as drill, practice, tutorial, simulation. Instructional units will be programmed in the BASIC language. Prerequisite: consent of program director. Mr. Tuscher.

391-392. Workshop (1-3)
Cooperative study of current educational problems. Designed

to provide elementary and secondary school teachers an opportunity to work at their own teaching levels and in their own fields. Students will be limited to six credits during a summer session but may register for more than one workshop provided there is no duplication in subject matter.

393. Instructional Media (3)
Study of principles underlying the use of graphic and sound projection in teaching. Utilization of commercial, student, and teacher made materials. Applications of new instructional media such as television, teaching machines, and computer-assisted instruction to classroom teaching. Mr. Ray.

For Graduates

400. Psychological Foundations of Education (3) fall-spring
Psychological study of student development and the classroom environment.

401. Sociological Foundations of Education (3) fall-spring
Analysis of the American school as a social institution, its cultural heritage, its purposes and processes in relation to social change and educational leadership. Examination of the school's role in socialization and its responsibilities for relevance to social issues and to subcultural needs. A. Rinehart.

403. Teaching in the Two-Year College (3)
Major theories of teaching, learning, and measurement are studied with particular reference to the problems of instruction in the two-year college. The characteristics of students in two-year colleges are examined. Participants undertake research in the field. Mr. Guditus.

406. Historical Foundations of Education (3) fall-spring
The developments of primary, secondary, and higher education; the aims, curricula, methods, and systems of education from early times to the present, in relation to the social conditions and processes. Mr. Leight.

407. Philosophical Foundations of Education (3) fall-spring
Comparative philosophical analysis of educational aims, practices, and institutions. Major philosophical theorists whose work has influenced educational thought from ancient times to the present are studied. Messrs. Baus, Leight, and Stoops.

408. Comparative Education (3) fall-spring
A survey of educational practices abroad including all programs from nursery to graduate education. Major emphasis is placed upon systems of articulation, social foundations, legal foundations, and structure in government. The nature and purposes of the schools are considered with particular reference to cultural patterns. Focus is also placed upon major problems and trends. Mr. Warfel.

409. The Two-Year College (3)
Historical and philosophical analysis of the two-year college as an institutional mode in American higher education. The unique nature of the two-year college is considered in relation to its service functions and the values in American higher education. Participants undertake research in the field.

410. Structure and Syntax of the Academic Disciplines (3)
Professors from other departments of the University are presented in discussions coordinated by the School of Education. The patterns which organize and identify the academic disciplines are emphasized. Study is given the nature and significance of the conceptual structures which guide inquiry or research in certain major fields of scholarship. Implications for planning of curricula and preparations of teaching materials are considered.

411. Personality and Adjustment (3) fall
Theories of personality and adjustment are examined with emphasis on the adjustment processes in an educational setting. Prerequisite: consent of the program director. Mr. Edmiston.

412. Individual Assessment and Interviewing (3)
Various assessment procedures used in school settings including interviewing, observational techniques, and individual psychological testing. Prerequisite: consent of program director. Mrs. Grandovic.

413. Theories of Psychological Counseling (3) spring
Analysis and synthesis of concepts drawn from counseling theorists. The research and current trends in counseling concerning educational, social, and vocational problems are studied. Prerequisite: admission to program in counselor education. Mr. Edmiston.

414. Child Development (3) fall-spring
A study of physical, intellectual, emotional, and social aspects of child development as they relate to the elementary schools. Mr. Castaldi.

415. Developmental Learning Clinic (3)
Special education students with training in learning disabilities cooperate with school psychologists, reading specialists, and counselors in the assessment and formulation of prescriptive programs for children with special learning problems. Prerequisite: consent of program director. May be repeated for credit.

416. Classroom Didactics (3-6)
Initial preparation of interns for classroom teaching. Secondary interns are trained in special methods of subject fields and the reading problems of secondary students. Elementary interns study the place of subjects in the elementary school. Open to interns only.

418. Values and Educational Purpose (3)
Modes of philosophical analysis used in justification of educational purposes. The presence of metaphysical, epistemological, and metaethical premises in educational opinion. Canons of rational inquiry as applied to educational decisions. Manifestations of values in contemporary school curricula. Prerequisite: Educ. 407. Messrs. Leight and Stoops.

422. Education of Exceptional Children (3)
Curriculum, methods of instruction, and materials for individuals who differ markedly from the normal intellectually,

physically, emotionally, or socially; the nature and causes of these differences; available resources. Field trips; direct work with exceptional encouraged. Mrs. Grandovic.

423. Diagnostic and Remedial Teaching (3)
The role of the classroom teacher as a diagnostician of corrective learning difficulties. Emphasis is placed on the nature and methods of educational diagnosis and the specifics of diagnostic teaching important to daily classroom instruction at all levels. Opportunities are offered for experiences in diagnosis and program prescription.

424. Linguistics in Education (3)
Emphasis on the nature of language, phonetic applications, and the relationships of linguistics to instruction in the language arts.

425. Diagnosis and Adjustment of Reading Difficulties (3)
A survey of problems in diagnosing and adjusting reading difficulties. The psychology of reading as related to learning difficulties; the measurement and diagnosis of reading difficulties; the development of informal tests for identifying reading difficulties; materials for corrective and/or remedial instruction. Prerequisite: Educ. 431 or consent of dean. Messrs. Kender and Heydenberk.

426. Independent Study and Research (3-15)
Individual or small group study in the field of specialization. Approved and supervised by the major advisor. Not more than six credits may be earned in a semester.

427. Participation in Teaching (3)
Study, directed observation of, and initial practice in the various phases of teaching in a campus laboratory-demonstration school or in area elementary and secondary schools.

428. Intern Teaching (3-6)
Intensive practice in the application of the principles of teaching. Each intern is appointed to a full-time teaching position for one or two semesters. Supervision is provided both by the employing school district or community college and by the University. Prerequisite: Educ. 427.

429. Intern Teaching Seminar (3)
Critical analysis and discussion of classroom instructional practices. Discussion and illustration will be based on the experiences of participants as they engage in intern teaching. Education 428 required concurrently.

431. Developmental Reading (3) fall-spring
Introductory course spanning the elementary and secondary levels. Emphasis on the history of reading instruction, basic premises in reading, the sequence of language development, directed reading activities and reading in content areas. Mr. Heydenberk.

434. Mathematics in Elementary Education (3)

435. Social Studies in Elementary Education (3) Mr. Warfel.

436. Science in Elementary Education (3)

437. 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.

438. Fine Arts in Elementary Education (3)

443. Elementary School Administration (3)
The major problems of organization and administration of elementary schools; types of organization, pupil promotion, time allotment, service agencies, and plant and equipment. Required for a principal's certificate. Mr. Pickering.

444. The Elementary School Curriculum (3)
Problems of curriculum development in the first six grades; subject matter placement, program-making for difficult types of schools, regular vs. special subjects, articulation, and similar problems. Mrs. Lifland.

447. Seminar in Reading Research (3)
An advanced course dealing with critical appraisal and discussion of classical and current studies in reading. Mr. Kender.

449. Children's Literature in Reading Instruction (3)
A consideration of the role of literature in the instructional program of the elementary schools. Emphasis is given the use of trade books for individual instruction in reading. Mesdames Larrick and Parr.

451. Learning Disabilities (3)
Types of specific learning disabilities and their effects on development and learning; physiological basis of learning and learning theory; various theoretical approaches; diagnostic and remedial procedures.

452. Learning Disabilities Practicum (3)
A 90-hour practicum in the assessment and remediation of learning disabilities.

453. Secondary School Administration (3)
The major problems of organization and administration of secondary schools; program of studies, teaching staff, pupil personnel, plant and equipment, and community relationships. Required for a principal's certificate. Mr. Keim.

454. The Secondary School Curriculum (3)
Methods of study of curriculum problems, selection of subject matter in various fields, principles of program construction, and similar problems. Mr. Keim.

455. Statistics I (3) fall
Data reduction, characteristics of frequency distributions, bivariate correlation and regression. Hypothesis testing, interval estimation, errors of inference, statistical power. Normal t, F, and Chi-square sampling distributions.

456. Statistics II (3) spring
One-way and factorial analysis of variance and covariance.

Multiple correlation and regression partial and part correlation. Use of packaged programs for computer analysis. Prerequisite: Educ. 455 or consent of the program director. Mr. Lutz.

457. Statistics III (3) fall
Analysis of variance and covariance in higher order experimental designs including factorial, incomplete factorial, nested, and repeated measures. Linear models approach. Use of packaged programs for computer analysis. Prerequisite: consent of the program director. Mr. Lutz.

458. Computer Applications (3) spring
Writing and testing computer programs and the use and adaptation of packaged programs; applications in behavioral research and in administration and instruction. Prerequisite: Educ. 455 or 459. Mr. March.

459. Methods of Statistical Inference and Research Design (3) spring
Introduction to packaged programs for computer analysis. Analysis of variance and covariance in experimental designs. Multiple correlation and regression. Prerequisite: Educ. 351 or 455, or consent of dean.

460. Group Counseling and Group Processes (3) fall-spring
Study of group processes as related to counseling and guidance through class participation and demonstration. Prerequisite: Educ. 483 previously or concurrently. Messrs. Mierzwa and Stillman.

461. Measurement Specialists Clinic (6) summer
Students construct an evaluative instrument, field test it with an appropriate sample and perform indicated analyses. A test manual will be prepared. Prerequisite: Educ. 472. Mr. Miller.

462. Criterion and Performance Based Evaluation (3)
Overview of measurement and evaluation theory and techniques with particular reference to criterion based performance evaluation in vocational and career education.

463. Public School Administration (3) fall-spring
A systematic treatment of the problems of administration, local, state and national. The newer developments which are modifying educational administration; state authorization and organization, the board of education, the superintendent of schools, personnel management, business administration, financial support, and public relations. Messrs. Gaffney and Guditus.

464. Foundations of Curriculum Construction (3) fall-spring
Principles of curriculum construction which underlie the reorganization of the program of studies for elementary and secondary schools; origin and background of the curriculum; methods of organization; curriculum planning and development; and pertinent applications. K-12. Mr. Pickering.

465. Administration of Higher Education (3)
Analysis of legal foundations, administrative controls, and operational patterns of the various types of higher institutions with special emphasis on the two-year college. Coverage of traditions which establish duties, responsibilities, and rights of faculty, administration, and board of control in American colleges. Messrs. Christensen and Guditus.

466. Supervision of Instruction (3)
Analysis of the principles underlying the organization and supervision of instruction; application to specific teaching situations. No lines will be drawn between the elementary and the secondary school. Mr. Guditus.

467. Current Issues in Counseling (3)
Examination of an area of counseling that is of topical interest to students and faculty. Permission of program director required. May be repeated for credit.

468. Administration of Student Service in Higher Education (3)
Study of the broad scope of the administration of student services in higher education including welfare functions, control functions, activities functions, and teaching functions. Emphasis to be placed upon matter of organization and operation, the place of these patterns in the total operation of the institution, and the administrator's role in the development and implementation of appropriate policies and practices affecting students. Mr. Guditus.

469. Practicum in Supervision of Reading Programs (3-6)
For candidates for supervisor's certificate in reading. An overview of the organization of the instructional program and the specific duties involved in the supervisory processes in reading programs. Students will observe and participate in supervisory activities. If taken as a three-hour course, may be repeated for a maximum of six credits.

470. Multivariate Analysis (3) spring
Multinormal sampling distribution. Multivariate tests of significance, interval estimation, analysis of variance and covariance. Discriminant analysis, canonical correlation, introduction to factor analysis. Use of packaged programs for computer analysis. Prerequisite: Educ. 457 or consent of program director. Mr. Lutz.

471. Evaluation in Education (3) fall-spring
Primarily for teachers and counselors. 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. Mr. Lutz.

472. Psychometric Theory (3) spring
Primarily for specialists in measurements and research. Theory of measurement as applied to various kinds of tests and scales. Item analysis: pre-testing, scaling and equating; errors of measurement; reliability and validity; prediction; factor analysis in test development. Prerequisite: Educ. 455 or permission of the program director. Mr. Miller.

473. Collective Bargaining in the Schools (3)
Contract negotiations, grievance, mediation, and arbitration for both professional and classified employees in education. Mr. Gaffney.

474. Seminar in School Building (3)
The design, construction, and modernization of educational facilities in terms of student, curricular, community, and financial requirements.

475. Seminar in Business Management (3)
Systems designed to support educational decision-making. Analysis of conceptual designs for planning-programming-budgeting and evaluation systems (PPBS).

476. Seminar in School Finance (3)
Concepts of school finance including intergovernmental fiscal relations, state grants-in-aid, taxation, municipal borrowing, long-term capital outlay programs, etc. An examination of school business office operations is included. Mr. Gaffney.

477. Seminar in School-Community Relations (3)
Analysis and development of the communication and public relations skills needed by educators involved in dealing with the public.

478. Seminar in School Personnel Problems (3)
Overview of the personnel function in educational institutions. Emphasis upon emerging trends in staff planning, recruitment, selection, assignment, and orientation, as well as tenure, grievances, and related matters. Mr. Keim.

479. Seminar in School Law (3)
The effect of school law upon the administration of public school systems, including analysis and synthesis of judicial interpretations of the constitutions, statutes, rules, regulations, and common law relating to educational issues. Mr. Gaffney.

480. Elementary School Guidance (3) spring
Analysis of roles of counselors, teachers, parents, and other specialists and their influence upon the development of the child. Practical concerns are emphasized. Prerequisite: Educ. 482 and consent of division director. Mr. Stafford.

481. Assessment in School Psychology (3-6)
Assessment processes used in school psychology. Practice in the administration of tests and preparation of school psychological reports is emphasized. Prerequisite: admission to program in school psychology. Messrs. Mierzwa and Wisser.

482. Philosophy and Principles of Guidance (3) fall
Theoretical foundations, principles, and ethics of guidance processes are considered together with the functions, services, and organization of an educational guidance program. Mr. Stafford.

483. Counseling (3) fall-spring
Intensive examination of theories and techniques of counseling. Students will practice counseling skills. Prerequisite: admission to program in counselor education. Messrs. Palmo and Stillman.

484. Career Development (3)
Study of the process of selecting and pursuing educational and vocational goals with an emphasis upon decision-making. Career development is examined as a facet of general human development. Evaluating and using occupational, educational, and related information. Mr. Palmo.

485. School Principals Clinic (3-6) spring
Simulated Materials Workshop on administrative decision-making open to practicing and prospective elementary and secondary school administrators. Mr. Tuscher.

487. Counseling and School Psychology Clinic (3-12)
Offered each semester. Mr. Mierzwa.

489. Reading Specialists Clinic (3-12) Mr. Kender.

491-492. Advanced Seminars in Education (3)

493. Research (3)
Basic principles of research and techniques of gathering and analyzing data. Exploration and comparison of various ways of bringing evidence to bear on the identification and solution of educational problems. Emphasis on critical reviews of research reports from various fields and representing various methodologies. A research report is required. Recommended to be taken before approval for master's candidacy.

494. Field Work (3-6)
Identification of significant problem(s) in an educational environment, review of the literature, and development of appropriate research plans. No more than three credits may be earned in a semester.

495. Educational Research Methodology (3)
For specialists in measurements and research. Study of experimental and quasi-experimental designs, methods of data collection, and instrumentation appropriate for use in educational settings.

496. Seminar in Research (3)
For doctoral students. Research design and application to various kinds of educational problems; data collection and analysis. Seminar includes criticism and evaluation of student proposals and related research. May be repeated for a maximum of nine credits.

498. Internship (3-9)
Designed to give advanced students an opportunity to obtain practical experience. Conference hours for students and staff members will be devoted to discussion of work and problems encountered in the schools. Prerequisite: consent of program director.

Electrical Engineering

Professors

Alfred Kriss Susskind, S.M., *Chairman*
John J. Karakash, D.Eng., *Distinguished Professor and Dean of the College of Engineering and Physical Sciences*
Walter Emil Dahlke, Ph.D.
Nikolai Eberhardt, Ph.D.
Arthur Irving Larky, Ph.D.

Associate Professors

William Avon Barrett, Ph.D.
Bruce Dale Fritchman, Ph.D.
Carl Sanford Holzinger, Ph.D.
Daniel Leenov, Ph.D.
John George Ondria, Ph.D.
Kenneth Kai-Ming Tzeng, Ph.D.

Assistant Professors

Joseph Conklin Mixsell, Jr., Ph.D.
Frank H. Hielscher, Ph.D.
Peggy Anne Ota, Ph.D.

Instructors

Hans R. Gnerlich, M.S.
Donald Lee Talhelm, M.S.

Lecturers

David George Cole, M.S.
William Frederick Hecht, M.S.
John K. Redmon, M.S.

The electrical engineering curriculum has been formulated to provide a foundation for competence and growth in the many challenging areas in electrical engineering. These include electronic devices, communication, information and computing systems, control systems, electronic instrumentation, and electrical power systems. Within each area, graduates will find careers in a variety of directions: design, development, research, manufacturing, operations, production, field engineering, management or marketing.

The undergraduate program can also serve as a stepping stone into such related areas as bioengineering, computer science, system engineering, or management science. The curriculum provides a strong foundation for graduate study in these fields.

A basic assumption underlying the electrical engineering curriculum is that the variety of activities in which modern electrical engineers are engaged will continue to remain large, and so an appropriate curriculum must provide opportunity for mobility of the individual. The undergraduate curriculum also reflects the awareness that it should concentrate on broad fundamentals and not on the details of current engineering practice.

Subjects in physics and mathematics form one block of courses in the electrical engineering curriculum, because no matter which direction the individual will follow, a foundation in the basic sciences and mathematics is essential. Within electrical engineering, the physical sciences provide a foundation for theoretical and experimental studies of devices, such as transistors, microwave components, and energy converters. Mathematics provides the basis for the analytical study of device models and the tools for the analysis, design and exploitation of systems such as computers, communication networks, and information or control systems.

The required courses in electrical engineering contain the fundamentals of linear circuits and systems, electronic circuits, signal theory, computer hardware and software, physical electronics, electromagnetic theory, and energy conversion. Some of these courses include laboratory work; two upper-level laboratory subjects are also required.

About a quarter of the normal electrical engineering curriculum consists of approved electives and electives. The former are chosen with the consent of the advisor; the latter require no formal approval. Together, these two groupings provide opportunity for tailoring the individual's program according to his or her interests and goals. Some students use the electives for acquiring additional background in preparation for graduate study, which has become important as a consequence of the growth in the intellectual content of engineering and science. Others will select senior-year courses in preparation for entry into industry at the completion of the four-year program. Students are free to select from courses offered by other departments, and are encouraged to do so whenever it serves their individual needs. In this manner, they can prepare themselves for activities which straddle departmental boundaries, such as computer science, or for entry into professional schools, such as medicine or management. To maximize the benefits that the flexibility of the curriculum can offer, thorough planning in consultation with the advisor is recommended.

In common with all engineering curricula, the program in electrical engineering requires at least eight courses in the humanities or the social sciences. Some students will utilize this sequence to complete a minor program in one of the other colleges, such as a program in literature, government or economics. Advisors will assist individuals in making appropriate arrangements.

Recommended Sequence of Courses

Your attention is called to notes 1 and 2 below.

Freshman Year (see page 52)

Sophomore Year, First Semester (16 credit hours)

EE 11	Introduction to Computer Engineering (3)
Math 23	Analytic Geometry & Calculus III (4)
Phys 21, 22	Introductory Physics II & Lab (5)
Eco 1	Economics (4)

Sophomore Year, Second Semester (17 credit hours)

EE 20	Introduction to Circuit Theory (4)
Math 205	Linear Methods (3)
Phys 31	Introduction to Quantum Mechanics (3)
Mech 103	Principles of Mechanics (4)
	GS Requirement (3)

Junior Year, First Semester (14-17 credit hours)

EE 104	Linear Systems & Signals (4)
EE 105	Electronic Circuits (4)
Math 231	Probability and Statistics or
Math 309	Theory of Probability (3)
	GS Requirement (3)
	Elective (0-3)

Junior Year, Second Semester (17 credit hours)

EE 103	Physical Electronics (3)
EE 106	Electromechanics & Machines (3)
EE 231	Electric & Magnetic Fields (3)
EE 142	Junior Lab (2)
	Approved Elective (3)
	Elective (3)

Summer

EE 100	Industrial Employment

Senior Year, First Semester (15-18 credit hours)

EE 111	Proseminar (1)
EE 151	Senior Lab I (2)
EE 245	Electromagnetic Theory (3)
	Approved Electives (6)
	Elective (0-3)
	GS Requirement (3)

Senior Year, Second Semester (18 credit hours)

	Approved Electives (12)
	Elective (3)
	GS Requirement (3)

Note 1: Approved electives are subjects predominantly in the areas of science and technology. They are not restricted to offerings in the department of electrical engineering. Students must choose at least one elective in mathematics and at least one elective in either materials, thermodynamics, fluid mechanics, or physical chemistry.

Note 2: Several of the required courses scheduled above for the sophomore and junior year can be delayed, provided the advisor's approval is obtained.

11. Introduction to Computer Engineering (3) fall
Introduction to computer-system organization, data structures, and the basic concepts behind user-oriented languages. Machine structure; memory organization and its allocation for data aggregates; assembly language; number representation and arithmetic. Fundamental types of programming statements and program structure. Functions and procedures. Iteration and recursion. Prerequisite: Engr. 1 or equivalent experience in programming.

20. Introductory Circuit Theory (4) spring, summer
Introduction to methods for analyzing lumped circuits containing linear and nonlinear, time-invariant and time-varying, active and passive elements. Topics include: circuit elements, formulation of differential equations, mesh and node analysis, state equations, network functions, natural frequencies, complete response calculations, pole-zero analysis, network theorems. Includes a weekly laboratory and/or problem-solving session. Prerequisite: Math. 23.

100. Summer Work
Students are expected to spend at least eight weeks getting experience in some industrial organization, normally during the vacation following the junior year. A written report on the experience gained therein is due on or before November 1.

103. Physical Electronics (3) spring
Energy levels and band theory. Introduction to quantum statistics; electron emission and photoelectric effect; electron ballistics and applications. Conduction in metals and semiconductors; theory of p-n junctions and transistors; static and dynamic characteristics; equivalent circuits. Prerequisite: Phys. 31.

104. Linear Systems and Signals (4) fall
Transform theory, including continuous and discrete Fourier transforms, fast Fourier transform, bilateral and unilateral Laplace transforms, Hilbert transform and analytic signals. Application of transforms to the solution of linear system problems. Introductory treatment of signal theory including modulation, correlation and filtering. Sampling theorems and their application to digital signal processing. Prerequisite: E.E. 20.

105. Electronic Circuits (4) fall
Introduction to methods for analyzing and designing circuits containing semiconductor devices such as diodes, bipolar transistors, and field-effect transistors for both small and large-signal applications. Topics include operating-point stabilization, basic amplifier configurations, power relationships, graphical and mathematical analysis techniques, multistage amplifiers and feedback. Includes a weekly laboratory. Prerequisite: E.E. 20.

106. Electromechanics and Machines (3) spring
Principles of electromagnetism and their application in electromechanical devices. Analysis and design of transformers, solenoidal actuators, multi-phase power systems, AC and DC rotating machinery, and machine control. Prerequisite: E.E. 20.

111. Electrical Engineering Proseminar (1) fall
A weekly seminar to acquaint students with current topics in electrical engineering. Students prepare and present oral and written reports which are judged on skill of presentation and technical content. Prerequisite: senior standing.

142. Junior Lab (2) spring
Experimental work based on E.E. 103, 104, 105, and 106 intended to strengthen proficiency in these fields. Two three-hour laboratory sessions per week. Prerequisite: junior standing.

151. Senior Laboratory I (2) fall
Laboratory projects in any phase of electrical engineering, frequently in the areas of digital systems, communications, instrumentation, and electronic circuits. Projects are selected by the student from topics suggested by the students, staff, or industrial concerns. Two three-hour sessions per week. Prerequisite: senior standing.

152. Senior Laboratory II (2) spring
Two choices open, each occupying two three-hour sessions per week.
(1) Project laboratory. Similar to E.E. 151.
(2) Microwave laboratory. Introduction to the standard techniques of measurement in the microwave range, such as measurement of impedance with the slotted line and the hybrid tee; two-port parameters after Dechamps and Weissfloch; attenuation by substitution and heterodyning. Prerequisite: E.E. 346 previously or concurrently.

160. Introduction to Electrical Engineering (4) fall-spring
Survey subject for students not majoring in electrical engineering. Elementary network theory. Behavior of simple linear networks. Principles of semiconductor devices and their use in functional circuits. Electromechanical energy conversion. Selected applications. Includes a weekly recitation session for review and discussion of assignments. Prerequisites: Math. 23 and Phys. 21.

162. Electrical Laboratory (1) fall-spring
Experiments on circuits, machines, and electronic devices. Prerequisite: E.E. 160 concurrently.

For Advanced Undergraduates and Graduates

The following courses are departmental electives with the exception of E.E. 231 and E.E. 245.

201. Computer Architecture (3)
Digital building blocks, conventional computer structure and information flow. Mechanization of arithmetic, storage, and control functions. Input-output systems and controllers. Priority interrupt, direct memory access and other overlapping techniques. Architecture of small ("mini") computers; key features of large ("maxi") machines. Digital design simulation. Prerequisites: E.E. 11 or Math. 105; E.E. 241 previously or concurrently. Mr. Larky.

205. Pulse and Digital Circuits (3)
Analysis of functional circuits: wave shapers, multivibrators, logic circuits, pulse and timing generators. Models of semiconductor devices. Methods of nonlinear analysis and worst-case design. Feedback and negative resistance. Prerequisite: E.E. 105. Mr. Holzinger.

212. Control Systems (3)
Introduction to feedback control. Dynamic analysis of linear feedback systems in the time and frequency domain, with emphasis on stability and steady-state accuracy. Major analytical tools: signal-flow graphs, root-locus method, Nyquist plot, Bode analysis. Cascade compensation techniques. Introduction to sampled data and state-variable concepts. Prerequisite: E.E. 104. Mr. Talhelm.

231. Electric and Magnetic Fields (3) spring
Fundamentals of static electric and magnetic fields. Laplace's equation. Polarizability of matter. Boundary conditions. Conformal mapping. Numerical methods in potential theory. Prerequisite: junior standing.

233. Power System Analysis I (3)
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: E.E. 106. Mr. Hecht.

234. Power System Analysis II (3)
Application of short-circuit impedance matrix to fault studies. Numerical methods for solution of the load flow problem. Economic despatch and unit commitment. Basic system stability consideration. Prerequisite: E.E. 233. Mr. Cole.

241. Switching Theory and Logic Design (3)
Boolean algebra and its application to networks with bivalued signals. Function simplification and design of combinational logic. Sequential machines and their realization in pulse and level circuits. Design of simple digital systems. Messrs. Susskind and Tzeng.

244. Communication Networks (3)
Introductory theory of two-terminal and four-terminal network synthesis. Transmission lines as network elements. Analog and digital filter theory. Prerequisites: E.E. 104 and 105. Mr. Talhelm.

245. Electromagnetic Theory (3) fall
Maxwell's equations. Wave solutions in rectangular and cylindrical coordinate systems. Retarded potentials. Poynting's theorem. Lossy and lossless isotropic media. Skin effect. Transmission lines, waveguides, and resonant cavities. Prerequisite: E.E. 231.

300. Apprentice Teaching in E.E. (1-3)

307. Transistor Circuit Application (3)
Review of static and dynamic behavior of p-n junctions. Transistor physical electronics, volt-ampere characteristics, and circuit models. Dependence of circuit-model parameters on structure and operating conditions. Tuned amplifiers, feedback amplifiers, and oscillators. Prerequisite: E.E. 105. Mr. Ondria.

308. Transistor Theory (3)
Large-signal theory of p-n junction devices. Approximate large-signal models for analysis of switching, including Linvill, Ebers-Moll, and charge-control models. Deviations from low-level models at high injection levels. Theory of field-effect transistors and large-signal models. Prerequisite: E.E. 103. Mr. Leenov.

311. Compiler Design (3)
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. Recent developments, including dynamic storage allocation, table grammars, code optimization, compiler-writing languages. Prerequisite: consent of department chairman. Mr. Barrett.

315. Principles of Computer Software (3)
Machine, assembly and macro language concepts. Study of assemblers, macro processors, and loaders, and techniques for their construction. Introduction to operating systems as time permits. Prerequisite: E.E. 11 or consent of department chairman. Mrs. Ota.

317. (I.S. 317, Math 317) Analytical Methods for Information Sciences (3)
Series of topics in discrete mathematics chosen for their applicability to computer science, coding theory, and information retrieval. Sets; binary relations; lattices; Boolean algebras and application to logic design; semigroups and relevance to automota; groups and application to coding; fields and relevance to circuits and codes; graphs and application to file searching. Prerequisite: senior standing or consent of department chairman. Mr. Tzeng.

319. Digital System Design (3)
Design of combinational and sequential digital systems using standard logic elements, both SSI and MSI; characterization and application of flip-flops and other memory devices; input-output devices and the problems of interfacing to a computer; special-purpose digital systems. Prerequisite: E.E. 241. Mr. Larky.

321. Current Topics in Magnetics (3)
Topics drawn from current areas of magnetic device theory and application, such as ortho-ferrite bubbles, magneto-optics, magnetic thin films, ferrites, and permanent magnets. Text material taken primarily from the current literature, with emphasis on computer applications. No specialized background assumed. Prerequisite: consent of department chairman. Mr. Holzinger.

342. Communication Theory (3)
Theory and application of analog and digital modulation. Sampling theory with application to analog-to-digital and digital-to-analog conversion techniques. Time and frequency division multiplexing. Introduction to random processes including filtering and noise problems. Introduction to statistical communication theory with primary emphasis on optimum receiver principles. Prerequisites: E.E. 104 and Math. 309 or 231. Mr. Fritchman.

346. Microwave Circuits and Techniques (3)
Impedance transformation along waveguides. Matching techniques. Resonant cavities as circuit elements. Scattering and transfer matrices. Periodic structures. Selected microwave devices. Basic techniques of microwave measurements. Prerequisite: E.E. 245. Mr. Eberhardt.

350. Special Topics (3)
Selected topics in the field of electrical engineering not included in other courses.

351. Microelectronics (3)
Technology of semiconductor devices and of monolithic integrated circuits, including crystal growth and doping, phase diagrams, diffusion, epitaxy, thermal oxidation and oxide masking, photolithography, thin film formation. Effects of these processes on the design of transistors and integrated circuits. Prerequisite: E.E. 103 or consent of department chairman. Mr. Hielscher.

For Graduates

Graduate study leading to the M.S. and Ph.D. degrees is available in the electrical engineering department. Neither of the advanced-degree programs has a fixed curriculum, and courses are selected by the individual in consultation with the advisors.

In addition to the uniform requirements set forth by the graduate school, the electrical engineering department requires the submission of a satisfactory thesis for the master's degree, unless the candidate is able to demonstrate other research training.

Subject to approval by departmental advisors, graduate degree programs frequently include as part of the "major" courses offered by other departments. This is particularly appropriate in those areas where courses in physics and mathematics provide a foundation for advanced work.

Students in the Ph.D. program are required to take the qualifying examination within one year after obtaining the master's degree. This examination tests competence in general areas of electrical engineering. A second examination in the candidate's area of specialization is taken at some time up to the last year of his or her program. Competence in a foreign language is not a required part of the Ph.D. program in electrical engineering.

Members of the department are particularly interested in advanced work in the following areas: semiconductor devices; microwave components and circuits; electrooptics; magnetic memory devices; computer languages; computer hardware and software systems; communications and decision theory; pattern recognition; algebraic coding theory; switching theory and logical design.

The facilities of the electrical engineering department are located primarily in the James Ward Packard Laboratory of electrical and mechanical engineering. The electrical engineering department will also share the facilities of the Sherman

Fairchild Laboratory for Solid-State Studies, which will be under construction during 1975 and 1976. In common with all of the campus activities, ready access to Lehigh's CDC 6400 computer is available.

Facilities for experimental work in electronics and communication cover the spectrum through microwave frequencies and into optical wave lengths. Special research facilities, including a shielded room, are available for the study of devices, noise in semiconductor networks, and digital functions. A laboratory for microelectronic processing contains facilities for the investigation of semiconductor surfaces and for the preparation of special devices. These include facilities for oxidation, diffusion, photolithography, metallization, and wire bonding. The department has two PDP-8 minicomputers and a variety of ancillary building blocks.

For studies in the area of solid-state devices, facilities of other departments are available. These include X-ray facilities, electron microscope, scanning electron microscope, electron microprobe, and Auger spectrometer.

403. Design of Operating Systems (3)
Hardware and software desiderata for operating systems in both batch and interactive applications. Brief survey of contemporary systems. Detailed treatment of elements of executive systems, such as protection mechanisms, paging and segmentation, swapping, I/O and file systems, scheduling, fault handling, crash recovery. Techniques for actual construction of an executive system will be discussed as time permits. Mrs. Ota.

407. Linear and Nonlinear Optics (3)
Gaussian beams. Optical waveguides and resonators. Introduction to laser physics. Crystal optics with attention to nonlinear effects. Harmonic and subharmonic generation. Parametric amplifications. Brillouin and Raman scattering. Classical diffraction theory. Holography with applications. Mr. Eberhardt.

409. Advanced Electromagnetic Theory (3)
Maxwell's equations in the scope of modern physics. Wave propagation in anisotropic and gyrotropic media. Introduction to nonlinear media. Atmospheric propagation and scattering. Selected topics from antenna theory. Mr. Eberhardt.

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 sources, derivation of noiseless coding theorems, investigation of discrete and continuous memoryless channels, development of noisy channel coding theorems. Mr. Fritchman.

413. Active Networks (3)
Synthesis of active networks to prescribed frequency characteristics. Stability and realizability criteria. Parameter drift effects. Mr. Larky.

425. Power System Analysis I (3-6)
Distribution-system concepts and components: transformers; protective devices; voltage control; optimum loading; grounding. Protective relaying: operating principles and system calculations including fault calculations using symmetrical components. Surge phenomena: traveling-wave theory; grounding; surge-reduction design and arrester application; insulation coordination. Economics of power systems: analysis and evaluation of financial structure; rate of return; rate structures; depreciation. Mr. Redmon.

426. Power System Analysis II (3-6)
Analysis of synchronous machines. Steady-state and transient modes of operation; per unit representation; d-q equations; balanced and unbalanced short-circuit stability; saturation. Stability criteria of power systems. State functions and state variables; system modelling; computer techniques; state-of-the-art analysis techniques; dynamic stability. Mr. Redmon.

431. Topics in Switching Theory (3)
Emphasis on structural concepts motivated by recent advances in integrated circuit technology. Major topics include: logical completeness, error detection and location; decomposition techniques; synthesis with assumed network forms; fault masking in switching circuits. Prerequisite: E.E. 241 or equivalent. Mr. Susskind.

432. Finite State Machines (3)
Description of sequential behavior; Gedanken experiments; error control; information losslessness, iterative systems. Synthesis of sequential machines in canonic forms and as asychronous circuits. Prerequisite: E.E. 241 or equivalent. Mr. Susskind.

435. Coding Theory (3)
General theory of error-correcting codes for error control in digital computer and communication systems. Topics include a review of modern algebra as required in the discussion of codes; the structure and properties of linear, cyclic, and convolutional codes for random or burst-error correction (or both); decoding algorithms and their circuit implementations. Prerequisite: E.E. 317 or Math. 243 or equivalent. Mr. Tzeng.

444. Microwave Devices (3)
Optical masers. Cavity- and traveling wave masers. Devices using ferrimagnetic resonance: isolators, circulators, electronically controlled phase shifters. Parametric amplifiers. Amplifiers and oscillators using active semiconductor devices. Mr. Eberhardt.

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 the phenomena: 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. Mr. Eberhardt.

448. (M.E. 448) Optimal Control and Design Theory (3)
See M.E. 448 for description.

450. Special Topics (3)
Selected topics in the field of electrical engineering not covered in other courses.

451. Physics of Semiconductor Devices (3)
Energy band structure. Transport theory, lattice vibrations, electronic conduction. Theory of recombination. Applications of p-n junctions and metal-insulator-semiconductor structures. Prerequisites: Phys. 31 and E.E. 103 or equivalent. Mr. Dahlke.

452. Theory of IMPATT and Gunn Diodes (3)
Hot electrons, secondary ionization, avalanche breakdown, electron transfer by intervalley scattering. Applications to microwave oscillators and amplifiers, such as avalanche and Gunn diodes. Prerequisite: E.E. 451. Messrs. Dahlke and Leenov.

453. Theory of Field Effect and Tunneling Devices (3)
Properties of semiconductor surfaces; tunneling theory. Applications to tunnel diodes and field-effect transistors. Prerequisite: E.E. 451. Mr. Dahlke.

454. Theory of Optoelectronic Devices (3)
Optical electronics. Theory of radiation, radiative absorption and emission in semiconductors. Applications to optical electronic devices: electroluminescence, light emitting diodes, lasers. Detection and modulation of optical radiation, solar cells and photodetectors. Prerequisite: E.E. 451. Mr. Dahlke.

459. Fundamentals of Integrated Circuits (3)
Discussion of basic concepts which govern the design and performance of integrated circuits. Microelectronics technology, device physics and equivalent circuit models, effects of processing and parasitic elements on device performance. Circuit design considerations, with examples drawn from current linear and digital integrated circuits. Mr. Hielscher.

461. Theory of Electrical Noise (3)
Definitions: noise temperature, spectral density. Noise sources: quantum, thermal, shot, generation-recombination, flicker noise. Representation and optimization of noisy networks. Prerequisites: Phys. 31 and E.E. 103, or equivalent. Mr. Dahlke.

462. Noise in Microwave Devices and Networks (3)
Noise in electron tubes, bipolar and MOS transistors, mixers, parametric amplifiers, tunnel diodes, and masers. Prerequisite: E.E. 461. Mr. Dahlke.

English

Professors

Albert Edward Hartung, Ph.D., *Chairman*
Ray Livingston Armstrong, Ph.D.
Glenn James Christensen, Ph.D., *University Distinguished Professor*
Ernest Nevin Dilworth, Ph.D.
James Richard Frakes, Ph.D.
David Mason Greene, Ph.D.
Frank Scott Hook, Ph.D.
John W. Hunt, Ph.D., *Dean of the College of Arts and Science*
John F. Vickrey, Ph.D.

Associate Professors

Peter G. Beidler, Ph.D.
Addison Bross, Ph.D.
Jack Angelo DeBellis, Ph.D.
Edward J. Gallagher, Ph.D.
Robert R. Harson, Ph.D.
Eustace Anthony James, Ph.D.

Assistant Professors

Rosemarie Arbur, Ph.D.
Elizabeth Fifer, Ph.D.
George B. MacDonald, Ph.D.
Rosemary Mundhenk, Ph.D.
Barbara Traister, Ph.D.

Three majors are offered by the department of English: English literature, journalism and drama.

English Literature

Literature is a representation of life at the level of a person's individual, human dealings with others. It is man's response to the physical, emotional, intellectual, and moral conditions of his existence. A literary work is one author's ordering and interpretation of personal experience, revealing whatever wisdom and beauty his or her vision of the universe affords. It both illuminates human experience and is a joy forever.

When these works are seen as the diverse and yet unified expressions of an epoch, they provide insight into the human problem and solution at a particular moment in time. Put together epoch after epoch, they thus become, in a peculiarly rich and inward sense, a form of history. Among world literatures English is perhaps the most varied and splendid and, together with American literature, presents in today's international setting an unusual breadth of national, racial, regional, and cultural subjects.

The English major student will come to know the varied

richness of this literature. So that he or she may learn how to read thoughtfully and sensitively, the person will be taught how to analyze the basic processes of the literary art. The individual's own skill in using the written word will grow as he or she studies intensively the writings of those who have shown themselves to be the supreme masters of the skill. Above all, the student will be challenged to formulate honest reactions to the student reading just as writers originally did when confronted by experience; and so, by integrating one's own experience with what Matthew Arnold called "the best that has been thought and said," he or she will come to perceive whatever wisdom and beauty his or her own enriched vision will afford. The resulting enlargement of mind and spirit not only should produce a flexible, yet well-integrated, personality but also can be put at the service of society in whatever profession or enterprise the student may undertake.

Required Preliminary Courses

Engl 1, and 2, 10, 14, or 16	Composition and Literature (6)
Engl 8, 9	English Literature (6)

Required Major Courses

Engl 323, 324	Shakespeare & Elizabethan Drama (6)
	and twenty-four semester hours from the following courses:
Engl 183, 184	Readings in English Literature (6)
Engl 321, 322	Twentieth-Century Literature (6)
Engl 325	English Literature of the Romantic Era (3)
Engl 326	English Literature of the Victorian Era (3)
Engl 331	Milton (3)
Engl 333	Restoration and Augustan Literature (3)
Engl 334	The Age of Johnson (3)
Engl 335	History of the English Language (3)
Engl 336	Writing for Publication (3)
Engl 337	The Renaissance (3)
Engl 338	The Seventeenth Century (3)
Engl 339	Chaucer (3)
Engl 340	Advanced Composition (3)
Engl 341, 342	Contemporary Literature (6)
Engl 343	American Romanticism (3)
Engl 344	American Realism (3)
Engl 345	Themes in American Literature (3)
Engl 346	Middle English Literature (3)

Note: electives are to be chosen in consultation with the departmental major advisor to ensure adequate breadth of coverage.

Up to six hours of related courses in other departments may be substituted with the approval of the advisor.

Collateral courses are recommended in history, philosophy, religion studies, history and criticism of the fine arts, and classical and modern languages and literature. Students planning to pursue graduate studies should acquire a reading knowledge of at least one foreign language, preferably French, Latin, or German.

In addition the Department of English offers two minors, each requiring fifteen hours of course work beyond English 1 and 2, 10, 14, or 16 as follows:

Minor in English

6 hours - English 8 and 9
9 hours - any three English courses at the 300 level, excluding English 300, 336, and 340

Minor in American Literature

6 hours - English 23 and 24
9 hours - any three American literature courses at the 300 level (i.e., 313,315,318,319,321,341,343,344,345)

Undergraduate English Composition Courses

All students must meet the requirements of six semester hours in freshman composition. This may be done through satisfactory performance in English 1, the regular first semester freshman course, and in English 2, 10, 14, or 16, the regular second semester freshman courses. The student must elect one course from among the English 2, 10, 14, 16 offering. Advanced placement and six semester hours of Lehigh credit for English 1 and 2, 10, 14, or 16 are given to students who earn scores of 3 or higher on the CEEB Advanced Placement Test in English. Other students who earn a score of 700 or higher on the SAT-Verbal Aptitude Test receive equal credit.

1. Composition and Literature (3)
Practice in expository writing and the application of rhetorical principles based upon models.

2. Composition and Literature (3)
Continuation of English 1. Further practice in expository writing in conjunction with the study of the drama, the short story, and verse. Prerequisite: Engl. 1.

10. Composition and Literature: Short Fiction (3)
Continuation of English 1. Further practice in expository writing in conjunction with the study of short stories and novellas by masters of the form. Prerequisite: Engl. 1.

14. Composition and Literature: The Novel (3)
Continuation of English 1. Further practice in expository writing in conjunction with the study of major works in the form, both English and Continental. Prerequisite: Engl. 1.

16. Composition and Literature: Drama (3)
Continuation of English 1. Further practice in expository writing in conjunction with the study of the literary and theatrical aspects of a group of plays, classic and contemporary. Prerequisite: Engl. 1.

English Literature and Advanced Composition

Students wishing to major in English literature should take as preliminary work Engl. 8 and 9, or such equivalent courses as may be recommended by the chairman of the department. They should then elect a total of ten advanced English courses in the junior and senior years. Students working for honors take a course in which they prepare a thesis as part of the honors requirement.

4. A Study of the Drama (3) PU fall
Reading and critical study of the drama; theories of the drama; the drama and the stage; the drama as a criticism of life. Prerequisite: Engl. 2, 10, 14, or 16.

5. A Study of the Drama (3) PU spring
Continuation of Engl. 4. Prerequisite: Engl. 2, 10, 14, or 16.

7. A Study of the Short Story (3) PU
A critical study of the short story, English, American, and Continental. Class discussions, extensive collateral reading, and reports. Prerequisite: Engl. 2, 10, 14, or 16.

8. English Literature (3) PU fall
A survey of English literature from *Beowulf* through the Pre-Romantics, with selected readings. Prerequisite: Engl. 2, 10, 14, or 16.

9. English Literature (3) PU spring
A survey of English literature from Wordsworth to Auden. Prerequisite: Engl. 2, 10, 14, or 16.

18. The Novel (3) PU fall
A study of a selection of novels as noteworthy works of literature. Prerequisite: Engl. 2, 10, 14, or 16.

19. The Novel (3) PU spring
Chronological continuation of Engl. 18. Prerequisite: Engl. 2, 10, 14, or 16.

20. American Major Writers (3) PU fall
A study of selected major writers from the settlement of America to the middle of the nineteenth century. Prerequisite: Engl. 2, 10, 14, or 16.

21. American Major Writers (3) PU spring
A study of selected major writers from the middle of the nineteenth century to the present. Prerequisite: Engl. 2, 10, 14, or 16.

23. Survey of American Literature (3) PU fall
A survey of major and minor writers from the settlement of America to the middle of the nineteenth century. Required of American Studies majors; open to others. Prerequisite: Engl. 2, 10, 14, or 16.

24. Survey of American Literature (3) PU spring
A survey of major and minor writers from the middle of the nineteenth century to the present. Required of American Studies majors; open to others. Prerequisite: Engl. 2, 10, 14, or 16.

35. Poetry (3) PU alternate years
Analytical and critical reading of poetry, to provide such acquaintance with idiom and technique that poetry may be read with pleasure and understanding. Prerequisite: Engl. 2, 10, 14, or 16.

36. Masterpieces of World Literature (3) PU alternate years
A study of great works selected from the literature of epic poetry, the drama, the romance, philosophy, and the essay to illustrate the humanistic traditions of Western civilization. Prerequisite: Engl. 2, 10, 14, or 16.

91. Special Topics in English (3) PU
Study of a characteristic theme, mode, topos, or approach in English literature. Prerequisite: consent of chairman and Engl. 2, 10, 14, or 16.

92. Special Topics in English (3) PU
Continuation of English 91. Prerequisite: consent of chairman and Engl. 2, 10, 14, or 16.

142. Technical Writing (3)
Study and practice in forms and methods of technical exposition, description, definition, classification; the technical report, abstract. Prerequisite: Engl. 2, 10, 14, or 16.

149. Science Fiction (3)
Study of the genre with emphasis on its role as creator and reflector of attitudes toward scientific and technological advances. Mr. Gallagher.

150. (Phil. 150) Media and Values (3) alternate years
How media and values are formed and reformed by their mutual interaction. Combines humanistic criticism with philosophical analysis to study the principal media (the human body, language, film, television, architecture, art) through which human values arise and take their place in the world. Historical, existentialist, phenomenological and structuralist analyses are stressed. Individual student projects in media-value analysis or manipulation are required. Messrs. MacDonald and Haynes.

151. Introduction to Film (3) PU
A survey of western cinema with emphasis on the technical and aesthetic properties which distinguish film from the other arts. Prerequisite: senior standing and consent of chairman. Mr. MacDonald.

181. Undergraduate Thesis (3)
Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of chairman.

182. Undergraduate Thesis (3)
Continuation of Engl. 181. Prerequisite: consent of chairman.

183. Readings in English Literature (3)
Open to advanced students who wish to pursue special courses of reading in English literature. Prerequisite: consent of chairman.

184. Readings in English Literature (3)
Continuation of Engl. 183. Prerequisite: consent of chairman.

English Literature for Advanced Undergraduates and Graduates

The objective of the graduate program in English is not merely the impartation of knowledge, however wide or deep. Ra-

ther it is to instruct and train the student in the methods by which he or she may pursue the advanced study of literature and literary history. It is to train the person in the techniques of criticism and research, so that he or she may go beyond what has already been done and make an original contribution in advanced study. To this end, graduate instruction in the department is conducted chiefly by seminars in which enrollment is limited to an average of twelve students and there is opportunity for individual contact between the student and the professor who is guiding research.

Advanced degrees may be obtained in all areas of English and American literature. Members of the department are particularly interested in advanced work in Chaucer and medieval literature, in Shakespeare and Elizabethan drama, in twentieth-century literature, and in American literature. In 1974-75 25 Ph.D. and 73 M.A. candidates were enrolled in the graduate program in English.

Students desiring to qualify for graduate degrees in this department should have taken an undergraduate major in English with at least fifteen semester hours of advanced courses in English literature. Those with undergraduate deficiencies who are admitted though otherwise well qualified will be expected to make up such deficiencies in addition to satisfying the minimum requirements for the degree sought.

All candidates for the master's degree in English who expect to go on for the Ph.D. are required to complete successfully eight semester courses (twenty-four semester hours) and to write a thesis representing the equivalent of six hours of course work.

Master's degree candidates who do not wish to continue for the Ph.D. may, as an alternative option, receive the M.A. degree by successfully completing nine semester courses (twenty-seven semester hours) and passing an examination, preparation for which represents the equivalent of three hours of course work. Details of the examination are available from the director of graduate studies of the department.

If the student's needs and interest make it desirable to do so, the candidate for the master's degree is permitted to take collateral work in other departments to the extent of six semester hours in lieu of an equivalent amount in the major field.

Candidates for the doctor's degree are accepted in English only after a consultation among the graduate professors concerning the candidate's qualifications. The foreign language requirement for the Ph.D. in English (usually in Latin, French, or German) may be satisfied in one of two ways: (1) the demonstration, through examination, of a reading knowledge of two foreign languages; or (2) the successful completion, concurrent with the graduate program, of a foreign language course, to be approved by the departmental Director of Graduate Studies, at the 200-, 300-, or 400-level (or at a lower level in classical languages). This second option may be used to satisfy a candidate's extra-departmental course requirement. Each candidate is required to schedule at least six hours of course work in History of the Language and Old English or, depending on previous preparation, six hours in Old English alone.

For the doctoral examination each candidate selects the following to be examined upon:

1. One of the following traditional periods:
Old English and Medieval
Renaissance and Jacobean, 1500-1660
Restoration and Eighteenth Century, 1660-1798
Romantic and Victorian, 1798-1900
American Literature, Colonial-1899
Modern British and American Literature, 1900-present.

2. A major figure (to be selected in consultation with the chairman of his doctoral committee and subject to the approval of the departmental graduate committee).

3. A genre, theme, matter, or customary grouping (to be selected in consultation with the chairman of the doctoral committee and subject to the approval of the departmental graduate committee).

In each of the three areas of the examination the candidate will be expected to demonstrate the knowledge and expertise that would be necessary if he or she were to teach a course in the subject. The three areas may not overlap-except for, in certain circumstances, the third.

313. The Indian in American Literature (3)
Study of the American Indian in literature by white and red writers, and of stereotypical roles of Indians in American fiction from the eighteenth century to the present. Mr. Beidler.

315. Early American Literature (3) alt. yrs.
A survey of American literature up to the Romantic period. Mr. Gallagher.

317. The Contemporary Drama (3)
A course in contemporary American and European drama with particular emphasis upon the development of social and philosophical conflicts of the present day. Ms. Fifer.

318. American Literature (3)
Movements that have shaped American thought and feelings as expressed in the national literature: Puritanism, Americanism, Romanticism, Transcendentalism, Individualism, the Civil War, Democracy, the West, Realism, Internationalism, and Skepticism, as presented by Jonathan Edwards, Franklin, Paine, Longfellow, Poe, Emerson, Thoreau, Mark Twain, Henry James, and Henry Adams.

319. The Black in American Literature (3) alt. yrs.
The characterization of the black and the literary treatment of the black experience in American fiction and drama from 1850 to the present. A comparative examination of both black and white authors, such as H. B. Stowe, W. W. Brown, Melville, Twain, Hughes, Toomer, Faulkner, Wright, Baldwin, Ellison, Styron, and Jones. Prerequisite: consent of chairman. Mr. Frakes.

320. The Novel (3)
The great masterpieces of prose fiction produced in England, in America, and on the Continent during the nineteenth and twentieth centuries; development of types of the novel; the theory and techniques of the novel.

321. Twentieth-Century American Literature (3) fall
American literature before World War II. Lectures and class

discussion of major fiction and poetry.

322. Twentieth-Century World Literature (3) spring
English and Continental literature before World War II. Lectures and class discussion of major fiction and poetry.

323. Shakespeare and the Elizabethan Drama (3) fall
The development of the English drama, including the important plays of Shakespeare. Mr. Hook.

324. Shakespeare and the Elizabethan Drama (3) spring
Continuation of Engl. 323. Mr. Hook.

325. English Literature of the Romantic Era (3) alt. yrs.
Poetry and prose of the chief romantic writers—Wordsworth, Coleridge, Scott, Byron, Shelley, Keats, Lamb, Hazlitt, De Quincey—with consideration of the political, religious, and social problems of the period as they are exhibited in the literature. Readings and class discussions. Mr. Harson.

326. English Literature of the Victorian Era (3) alt. yrs.
Poetry and prose of the chief Victorian writers—Tennyson, Browning, Arnold, Clough, Rossetti, Morris, Swinburne, Macaulay, Carlyle, Mill, Newman, Ruskin—with consideration of the political, religious, and social problems of the period as they are exhibited in the literature. Readings and class discussions. Mr. Bross.

331. Milton (3) alternate years
The life and works of John Milton in connection with the history of his times and chief sources of his inspiration. Mr. Greene.

333. Restoration and Augustan Literature (3) alt. yrs.
Prose and poetry from 1660 to 1745, with special emphasis upon the works of Dryden, Pope, and Swift. Mr. Dilworth.

334. Age of Johnson (3) alternate years
English prose and poetry in the middle and later years of the eighteenth century. Dr. Johnson and his circle, and others from Fielding to Blake. Mr. Dilworth.

336. Writing for Publication (3)
Comprehensive study of the short story and practice in the various techniques of writing short stories, essays, and poems with a view to publication.

337. The Renaissance (3) alternate years
The growth of English non-dramatic literature in the sixteenth century and the stimulus of the Italian Renaissance and northern humanism. Readings in and class discussions of the works of the chief writers—Petrarch, Erasmus, More, Wyatt, Surrey, Lyly, Sidney, and Spenser. Mr. Greene.

338. The Seventeenth Century (3) alternate years
The rich variety of English literature from Donne to Dryden—Donne and the "Metaphysical School"; Jonson and "The Tribe of Ben"; Cavalier and religious poetry; the prose of Bacon, Browne, Burton, Walton, and Bunyan. Ms. Traister.

339. Chaucer (3) alternate years
Reading and critical study of the chief works of Geoffrey Chaucer, with attention to his language and the backgrounds of his works. Mr. Beidler.

340. Principles of Advanced Composition (3)
A study of the principles and rhetorical forms of non-narrative prose with intensive practice in writing at an advanced level. Attention to the theory of language and grammar. Corollary readings, conferences, and class discussions. Prerequisite: English major standing or 2.5 average in freshman English.

341. Contemporary American Literature (3) fall
American literature since World War II. Lectures and class discussions of new writers and of recent works by established writers.

342. Contemporary World Literature (3) spring
English and Continental literature since World War II. Lectures and class discussions of new writers and of recent works by established writers.

343. American Romanticism (3) alternate years
A study of the chief American Romantics, Emerson, Thoreau, Whitman, Hawthorne, Melville, and Emily Dickinson. The European and American philosophical, historical, and social background as well as the formal aesthetic study of romantic masterpieces. Mr. DeBellis.

344. American Realism (3) alternate years
The rise of realism in prose and poetry in the period roughly from the 1870s to 1914; Twain, Howells, James, Robinson, Norris, Crane, Dreiser, and others. Mr. Frakes.

345. Themes in American Literature (3) spring
Intensive study of one topic in America literature. Readings from the colonial period to the present. Sample topics: the American rediscovery of Europe; the theme of apocalypse; American humor; the Edenic motif; personal revolt and social protest. May be repeated for credit. Primarily for majors in American Studies. Prerequisite: consent of director of American Studies. Mr. Frakes.

346. Middle English Literature (3) alternate years
A study of the major literary works of the Middle English period by authors other than Chaucer. Some works will be dealt with in translation, some in the original. In addition to such major figures as Langland, Gower, and the Pearl Poet, the metrical romances will be emphasized. Mr. Hartung.

347. Introduction to the English Language (3) alternate years
Study of some basic linguistic concepts together with a historical survey of the English language. Mr. Vickrey.

351. Experimental Literature: Form, Space, Time (3)
Study of experimental literature as it embodies and reflects new concepts in science and technology, with special emphasis on space, time, relativity, entropy. The literary work as

"model": form, structure, point of view, and technique as meaning. Kafka, Proust, Joyce, Robbe-Grillet, Borges, Woolf, Faulkner, Stein, Hawkes, Barth, Beckett, Pynchon, and others. Mr. Frakes.

For Graduates

400. Old English (3) alternate years
A study of the Old English language and literature. Mr. Vickrey.

401. Beowulf (3) alternate years
A study of the Beowulf poem and some of the pertinent scholarship. Mr. Vickrey.

403. History of the English Language (3)
Intensive study, with numerous exercises, of the phonology, grammar, and lexicon of English from the beginnings to the present. Mr. Vickrey.

404. Literature of the Fourteenth Century (3)
Types of medieval literature, with special attention to Langland, Gower, and the Pearl Poet. Mr. Beidler.

405. Chaucer (3) alternate years
A study of the life and works of Chaucer. Readings, reports and class discussions. Mr. Hartung.

406. Chaucer (3) alternate years
Continuation of Engl. 405. Mr. Hartung.

407. Middle English Metrical Romances (3)
A study of the Middle English non-Arthurian verse romances. Mr. Hartung.

408. Arthurian Literature of the Middle Ages (3) alt. yrs.
A study of the development of Arthurian literature from its Celtic beginnings to Malory's *Morte Darthur*. Mr. Hartung.

412. Shakespeare's History Plays (3)
A study of the English history plays as an introduction to advanced work in Shakespeare. Mr. Hook.

413. Shakespeare's Roman Plays (3)
An intensive critical study of *Julius Caesar, Antony and Cleopatra,* and *Coriolanus.* Mr. Hook.

414. Sixteenth-Century Drama (3)
A study of plays representing the development of English drama before Shakespeare. Mr. Hook.

415. Seventeenth-Century Drama (3)
A study of representative plays from the major Jacobean and Caroline dramatists. Mr. Hook.

417. Studies in Seventeenth-Century Literature (3)
Study of selected non-dramatic writers of the seventeenth century, with special attention to textual analysis and historical backgrounds. Ms. Traister.

444. Pope (3)
A study of the works of Pope and their literary background. Mr. Dilworth.

447. Eighteenth-Century Prose (3)
Studies in periodical prose, philosophical prose, satire, and the development of the novel. Mr. James.

448. Studies in the Eighteenth Century (3)
Studies in, and reports on, one or more authors or issues in eighteenth-century English literature.

450. Studies in British Romantic Literature (3)
Examination of various aspects of Romanticism including a study of one or more authors of the period. May be repeated for credit. Mr. Harson.

459. Studies in British Victorian Literature (3)
Study of one or more figures, a genre, or a literary movement in the Victorian period. May be repeated for credit. Mr. Bross.

461. Conrad (3)
A study of Conrad's major novels and tales, with emphasis on the author's style, technique, and attitude. Mr. Greene.

465. Joyce (3)
A sequential study of the works of James Joyce, their place in Irish and world literature, and their influence on twentieth-century prose. Mr. Frakes.

471. Seminar in Early American Literature (3)
Intensive study of the literature of colonial America and the early Republic. Mr. Gallagher.

474. Seminar in American Romanticism (3)
Poe, Hawthorne, Emerson, Melville, Thoreau, Whitman, Dickinson: intensive study of the work of one or more of these authors. May be repeated for credit.

475. Seminar in American Realism (3)
James, Twain, Howells, Crane, Dreiser, and others: intensive study of the work of one or more of these authors. May be repeated for credit.

477. Seminar in Modern American Literature (3)
Intensive study of the literature produced, after World War I, by one or more major authors. May be repeated for credit. Sample offerings: Faulkner, Hemingway and Stein; Southern writers; Frost and Stevens; et al.

486. Literary Criticism I (3)
Inquiry into the nature and function of literature, the nature of the critical act. Analysis and application of critical statements by major literary theorists. Ms. Arbur.

487. Literary Criticism II (3)
Analysis of modern critical approaches (psychoanalytic, formalist, archetypal, et al) applied to the practice of reading, teaching, and writing about literary works. Ms. Arbur.

490. Special Topics (3)
Selected topics in the field of English not covered in other courses. May be repeated for credit. Prerequisite: consent of department chairman.

491. Special Topics (3)
Selected topics in the field of English not covered in other courses. May be repeated for credit. Prerequisite: consent of department chairman.

492. Bibliography and Methods of Research (3)
A study of the bibliographical tools essential to an advanced student of English literature. Survey of historical, or critical bibliography, of both printed books and manuscripts; of practical bibliography, including direction in the compilation of a list of books and articles on an assigned subject and in the procedures of thesis writing; and of enumerative bibliographies of English language and literature.

493. The Teaching of College English (2)
The principles and practice of teaching composition, prose, and other literature on the college level. A consideration of standards, organization, grammar, diction, and style in student writing and the adaptation of a student writing program to readings in prose and other literature. Class discussions, actual teaching, and reports.

494. The Teaching of College English (1)
Continuation of Engl. 493.

496. Graduate Seminar (3)
Intensive study of the works of one or more English or American authors, or of a type of literature, or of the teaching of an author or a type of literature. Subject and instructor vary from semester to semester. May be repeated for credit as topic varies.

497. Graduate Seminar (3)
Same as Engl. 496.

498. Graduate Thesis (3)

499. Graduate Thesis (3)

Division of Journalism

Professors

Joseph Brendan McFadden, M.A., *Head*
Robert Joseph Sullivan, M.A.

Assistant Professor

Sharon M. Friedman, M.A.

Journalism is concerned with the exercise of social responsibility in human affairs. The profession of journalism deals with the truthful communication of facts and their explanation. It is the purpose of the program in journalism to bring its majors: (1) to the point where they can gather significant information, organize it quickly into effective form, and communicate it clearly, accurately, and with a disciplined objectivity; and (2) to an understanding of the legitimate role of the press in society.

The first of these objectives is obtained by extensive, professionally oriented practice in the writing, reporting, and editing of news. The skill thus acquired is firmly rooted in rigorous training in vocabulary, in precision of expression, and in sophistication in style. It is concerned with clear writing and careful reporting, the kind that depicts the meaning of events. It develops from a purposeful curiosity and a capacity to be imaginatively interested in human activity. The second objective is obtained: (1) by study of the rights and responsibilities of the press under the constitution, with emphasis upon the freedom of the press as conditioned by the liberties of the individual and the needs of society; (2) by examination of the journalistic tradition in the United States in relation to the political, economic, and social progress of the population; and (3) by independent study, culminating in an undergraduate thesis, of the press and society.

The basic program in journalism provides opportunity for concentration in at least one of the following areas: American studies, business management, economics, government, history, international relations, languages, literature, philosophy, religion studies, science, social relations, and urban studies.

While the great majority of graduates in journalism enter some phase of written communication as a career—daily newspaper, wire services, magazine, public or industrial relations, advertising, technical writing—others have used their background in journalism as a base for the study and practice of law, service in government, teaching, business management, and graduate study in a variety of disciplines.

Required Preliminary Courses

Journ 1, 2	Brown and White (2)
Journ 11	News Writing (3)

Required Major Courses

Journ 3-8	Brown and White (2-6)
Journ 12	Reporting of Public Affairs (3)
Journ 17	Magazine Article Writing (3)
Journ 113	Editing (3)
Journ 115	Interpretive Writing (3)
Journ 120	Journalism Proseminar (3)
Journ 121, 122	Law of the Press (6)

Note: *Brown and White* must be rostered each semester while the student is a journalism major, and a minimum of four such semesters is required. With the approval of the journalism faculty, current professional newspaper experience may be substituted semester for semester.

Recommended Electives

Journalism majors are encouraged to concentrate their elective courses in one or two areas. (See concentration areas in third paragraph, above.) Areas and elective courses should be chosen in consultation with the major advisor.

Newspaper Apprenticeships

With the approval of the journalism faculty, qualified majors may acquire professional experience in apprenticeships with regional newspapers.

Journalism Minor

Students who wish to declare a minor program in journalism must be majors in another discipline and take the following courses:

Journ 1-3	Brown and White (3)
Journ 11	News Writing (3)
Journ 113	Editing (3)
Journ 115	Interpretive Writing (3)
Journ 122	Law of the Press II (3)

1-10. Brown and White (1 or 2)
Enrollment constitutes membership on the staff of the semi-weekly paper. Students enrolling for their first semester register for Journ. 1; for their second semester, Journ. 2, etc. Prerequisite: consent of division head.

11. News Writing (3)
Definition, determinants, and components of news; news story structure and style; sources; interviewing; practice in gathering and writing news. Offered each semester. Mr. Sullivan and Mrs. Friedman.

12. Reporting of Public Affairs (3) spring
Reporting and writing news of government on the local, county, state, and federal levels; civil and criminal courts; labor, science, and entertainment news. Prerequisite: Journ. 11. Mr. Sullivan and Mrs. Friedman.

17. Magazine Article Writing (3) fall
Writing and marketing non-fiction magazine articles. Mr. McFadden.

21. Creative Writing (3)
The study and writing of fiction, short-stories, especially with a view to developing each student's particular talent. Prerequisite: consent of division head and Engl. 2, 10, 14, or 16. Mr. McFadden.

22. Creative Writing (3)
Continuation of Journ. 21. Prerequisite: consent of division head and Engl. 2, 10, 14, or 16. Mr. McFadden.

111. Problems in Advanced Reportage (3)
Intensive practice in the reporting of complex events.

112. Problems in Advanced Reportage (3)
Continuation of Journ. 111.

113. Editing (3) fall
Study of and practice in newspaper desk work; headline writing, make-up, and typography; selecting, editing, and rewriting news and feature copy; use of reference works and newspaper libraries. Prerequisite: Journ. 11. Mr. Sullivan.

115. Interpretive Writing (3) spring
Editorial interpretation of current events; practice in interpretive writing, including editorials. Prerequisite: Journ. 11. Mr. Sullivan.

118. History of American Journalism (3)
English background of the American newspaper; development of press from Colonial days to the present; influence of newspapers on American life; contributions of outstanding journalists. Mrs. Friedman.

120. Journalism Proseminar (3) fall
Survey of the press in its relation to public affairs. Extensive research and reports. Prerequisite: consent of division head. Mr. McFadden.

121. Law of the Press (3)
Constitutional development of freedom of the press; rights and responsibilities of the press. Mr. McFadden.

122. Law of the Press II (3) spring
Law of and defenses in libel; privacy; contempt; copyright; obscenity. Mr. McFadden.

311. Science Writing (3)
Study of and practice in writing about science and technology for general print, electronic media, and specialized science publications. Emphasis on writing skills and on science communication theory. Prerequisite: six hours of science or consent of division head. Mrs. Friedman.

312. Science Writing (3)
Continuation of Journ. 311. Prerequisite: Journ. 311. Mrs. Friedman.

Division of Speech and Dramatics

Professor

Frank Scott Hook, Ph.D.

Associate Professors

Thoburn Vail Barker, M.A.
John Pearson, M.F.A., *Head*

Assistant Professor

Marshall L. Kaufman, M.A.

Drama as a form of expression has been characterized as bordering many areas of knowledge. It is an art with spiritual and social vision. It celebrates, for participant and spectator, the phenomenon of communication and interaction.

The Division of Speech and Drama provides training and practice in using the implements of drama in a variety of communicative situations. Students probe the aesthetics of theatre; they investigate drama as a means of disseminating information; they find the bond between drama and the community; they practice the theatre of release, joy and recreation.

The B.A. in drama is given after a program of study including the traditional skills of the theatre: acting, directing, playwriting, design, lighting, movement and production. During instruction, students are encouraged to take part in the productions of the Mustard and Cheese drama organization, the Student Directors' Forum and the Black Theatre Ensemble. Students work with faculty and visiting professionals in preparing these productions.

The major in drama requires a minimum of thirty hours of course credit. However, the division encourages students to consider interdisciplinary and double majors as well, in order to enjoy broader opportunities for the application of their theatrical skills.

The division offers an example of community outreach in the application of theatre techniques each summer. In collaboration with the School of Education and Summer Sessions and the Bethlehem Department of Parks and Recreation, the division sponsors a Playground Touring Troupe. This group performs for and plays theatre games with the children on Bethlehem playgrounds throughout the summer.

Graduates with backgrounds in drama are prepared for graduate work (in M.A. or M.F.A. programs) or for professional apprenticeship programs. The drama program also attempts to prepare students to apply their talents and training to a wide variety of related or associated fields such as communications, education, the study of literature, fine arts, music, recreation and the social sciences.

Recommended Prelininary Courses

Engl 4,5	A Study of the Drama (6)
Dr 11, 12, 13	Basic Production (3)

Required Major Courses

Dr 41	Basic Techniques of Acting (3)
Dr 45	Basic Design and Technical Theatre (3)
Dr 61	Theatre Production (3)
Dr 144	Basic Directing (3)
Dr 301	History of the Theatre (3)
Dr 302	History of the Theatre (3)
Dr 341	Advanced Acting (3)
Dr 343	Basic Movement for the Stage (3)

and six hours from the following courses:

Dr 345	Advanced Design (3)
Dr 361	Advanced Directing (3)
Dr 363	Advanced Stagecraft (3)

Note: one of the following may be substituted for Drama 302 with the consent of the division head.

Fr 318	Theatre in the Twentieth Century (3)
Fr 417	Moliere (3)
Span 411	Twentieth Century Spanish Theatre (3)
Span 416	Spanish Theatre of the 17th Century (3)

Recommended Electives

Dr 42	Problems in Acting (3)
Dr 46	Lighting (3)
Sp 47	Oral Interpretation (3)
Dr 62	Theatre Production (3)
Sp 241	Phonetics (3)
Dr 371	Playwriting and Criticism (3)
Dr 381	Improvisational Acting (3)
Dr 383	Directing the Improvisational Ensemble (3)
Engl 317	Contemporary Drama (3)
Engl 323, 324	Shakespeare and Elizabethan Drama (3)
Music 1-2	Fundamentals (4)
Ger 101	The European Drama (3)
Gk 111	The Greek Drama (3)
Psych 121	Encountering Self and Others (3)
SR 304	Human Communication (3)
SR 305	Personality and Social Process (3)
SR 336	Anthropological Approaches to Religion (3)

Undergraduate Courses

11-13. Basic Production (1) fall-spring
The aesthetic process by which plays are translated into theatrical terms for the appreciation and enjoyment of all forms of dramatic arts. Students enrolling for their first semester register for Speech 11; for their second semester, Speech 12, etc. Prerequisite: consent of division head.

21-23. Impromptu Speaking (1)
The organization and presentation of short expository speeches and of speeches for special occasions. Content drawn from contemporary events. Students enrolling for their first semester register for Speech 21; for their second semester, Speech 22, etc. Prerequisite: consent of division head.

30. Fundamentals of Speech (3) fall-spring
A foundation course designed to develop knowledge of the basic principles of speech and ability to communicate.

31. Business and Professional Speaking (3)
Development of speech for business and professional problems: technique of expository speaking; use of visual graphics; persuasive speaking applied to the emotional or analytical approach in selling; methods of interviewing; techniques of conference. Prerequisite: consent of division head.

32. Conference and Discussion (3)
Techniques of investigation, analysis, inference, use of evidence, briefmaking, and refutation in oral argument; participation in the various forms of discussion—conference table, panel, and symposium. Prerequisite: consent of division head. Mr. Barker.

33. Parliamentary Procedure (1)
Study and drill in modern rules and methods of conducting organized group-deliberation.

34-36. Debate (1)
A study of the principles and techniques of debate, analysis, evidence, reasoning, refutation, briefing, speech composition, and delivery skills. Students enrolling for their first semester register for Speech 34; for their second semester, Speech 35, etc. Prerequisite: consent of the division head.

41. Basic Techniques of Acting (3) PU fall-spring
Techniques of the twentieth-century actor. Vocal production, stage movement, improvisational acting, characterization. Some laboratory projects in special areas. Some scene study.

42. Problems in Acting (3) PU
Solving the problems of the actor from the earliest times to the present. Some scene study; coordinating the craft of acting in all periods with the basic precepts of honesty in performance. Prerequisite: consent of division head or Drama 41.

45. Basic Design and Technical Theatre (3) PU
Study and practice of design concepts for the theatre designer. Includes history of theatre architecture. Mr. Kaufman.

46. Lighting (3) PU
Emphasis on the elements of creativity and their translation into the practice of stage lighting. Prerequisite: consent of division head or Drama 45. Mr. Kaufman.

47. Oral Interpretation (3)
The analysis and oral presentation of various types of literature. Consideration of sound values, rhythm, and imagery. Prerequisite: consent of division head. Mr. Barker.

48. Persuasion (3)
Study of and practice in persuasive techniques in salesmanship, political speaking, law and advertising. The ethical implications of persuasion. Prerequisite: consent of division head.

61. Theatre Production (3) fall-spring
Practical technique and production. Acting, stagelighting, scenic design and execution, and student direction of plays.

62. Theatre Production (3) PU fall-spring
Continuation of Speech 61. Prerequisite: Drama 61.

144. Basic Directing (3)
Survey of theatrical direction. Study of the emergence of the director. Prerequisite: consent of division head or Drama 41. Mr. Pearson.

For Advanced Undergraduates and Graduates

241. Phonetics (3)
Practice in the use of the international phonetic alphabet. Consideration of the standard speech characteristics of the three major American regional dialects. Prerequisite: consent of division head. Mr. Barker.

260. Speech for the Teacher (3)
An orientation course in the field of speech and dramatics for those engaged in classroom teaching.

301. History of the Theatre (3) alternate years
The history of the theatre in western Europe from ancient Greece to the Renaissance. Emphasis on audiences, theatrical structures, production methods, actors and acting styles. Some plays included, but whenever possible, students who have not had a course in history of the drama should schedule English 4 concurrently. Mr. Hook.

302. History of the Theatre (3) alternate years
Continuation of Drama 301 from the seventeenth to the twentieth century. Students who have not had a course in history of the drama should schedule English 5 concurrently when possible. Mr. Hook.

341. Advanced Acting (3) fall-spring
Extension of Drama 41. Further study of the actor's techniques with particular attention to problems presented by selected roles in world dramatic repertoire. Prerequisite: Drama 41 and 42 or consent of division head.

343. Basic Movement for the Stage (3)
Physical skills for actors. Includes basic choreography, stage-fighting and fight-choreography, basic pantomime, period and modern dances. Prerequisite: consent of division head. Mr. Pearson.

345. Advanced Design (3)
Continuation of Drama 45. Further study of the designer's ability to communicate visually to an audience. Particular emphasis on model building, drafting, and technical considerations. Prerequisite: Drama 45 or consent of division head. Mr. Kaufman.

361. Advanced Directing (3)
Extension of Drama 144. Student analysis and formulation of a directorial approach, culminating in the production of a full-length play. Prerequisite: Drama 144 or consent of division head. Mr. Pearson.

363. Advanced Stagecraft (3)
Study and practice in technical theatre, lighting, scenic construction. Investigation of innovations in theatre technology. Prerequisite: Drama 45, 61, or consent of division head. Mr. Kaufman.

371. Playwriting and Criticism (3)
Study of the resources and techniques of the dramatist. Critical analysis of the playwright's creative process and practice in creating smaller dramatic forms. Prerequisite: Drama 41, 61, 144 or consent of division head.

381. Improvisational Acting (3)
Improvisational and group theatre techniques. Improvisational performance from Commedia to Viola Spolin to the newer improvisational forms. Mr. Pearson.

383. Directing the Improvisational Ensemble (3)
The task of the ensemble guide in improvisational theatre of various kinds. Work with the experimental adult group as well as applications for creative dramatics and street theatre with children. Mr. Pearson.

Environmental Sciences and Resource Management

Edward B. Evenson, Ph.D., *Director of Environmental Sciences and Resources Management and Assistant Professor of Geological Sciences*

Society's increasing demands for energy, water, mineral commodities, food, recreational and living space have altered and will continue to alter the global ecosystem. The need for personnel trained to evaluate proposed alterations and repair existing deleterious or critical situations can best be met by an interdisciplinary approach.

Environmental Sciences and Resource Management is an interdepartmental major fostering basic preparation for advanced study or an immediate career in environmental management and conservation. The backgrounds of fundamental mathematics and science required to understand the complex of humans and their environment are established early in the major where the student is exposed to the core courses of mathematics, chemistry, physics, biology and geology. Following this basic preparation students select a concentration area within which more advanced training is undertaken. Concentrations in biology, chemistry, and geology have been established and concentrations in other fields can be designed to meet the needs and career desires of individual students.

Student research in specific problems involving laboratory, field, or library research is an integral part of the program and is strongly encouraged.

Graduates of this major can expect to take part in planning, education, research and coordination of environmental programs for all levels of government and industry. Graduate study is advisable for students wishing to pursue a career in most aspects of environmental science and the program provides thorough preparation for advanced training in environmental science or concentration areas.

Program for Bachelor of Science Degree (120 credit hours)

The credit for the program is allocated as follows: 36 credits for college and university requirements, 66 credits in preliminary courses, and 18 credit hours in the area of concentration.

College and University Requirements (36 credit hours)

Engl 1	Composition and Literature (3)
Engl 2, 10, 14, or 16	Composition and Literature (3)
	General Electives (30)

Note: General 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. The elective program shall include a large number of courses broadly distributed among the various areas of the humanities and the social sciences.

Required Preliminary Courses (66 credit hours)

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Math 23	Analytic Geometry and Calculus III (4)
Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Lab I (1)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
Chem 21	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Lab (1)
Chem 23	Analytical Environmental Chemistry (3)
Chem 51	Organic Chemistry (3)
Chem 53	Organic Chemistry Lab (1)
Geol 1	Principles of Geology or Geol 101 (3)
Geol 2	Introductory Geology Lab (1)
Geol 12	Historical Geology and Strat. (3)
Geol 33	Introductory Mineralogy and Petrology (3)
Geol 211	Environmental Geology (3)
Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Lab (1)
Biol 35	Microbiology (3)
Biol 306	Ecology (3)
Biol 331	Evolution of Non-Vascular Plants or
Biol 303	Invertebrate Zoology (3)
Eco 311	Environmental Economics (3)
CE 371	Environmental Health Engineering (3)

Concentrations (18 credit hours)

Students select and fulfill one of the following concentration areas.

Geology

Geol 23	Structural Geology (3)
Geol 212	Geomorphology and Quaternary Geology (3)
Geol 313	Sedimentation (3)
Geol 333	Crystallography (3)
Geol	Field Camp (6)

Biology

Biol 28	Genetics (3)
Biol 303	Invertebrate Zoology (3) or
Biol 332	Evolution of Vascular Plants (3)
Biol 309	Aquatic Biology (3)
Biol 322	Animal Physiology (3)
Biol 361	Sanitary Microbiology (3)
Chem 52	Organic Chemistry (3)

Chemistry

Chem 52	Organic Chemistry (3)
Chem 54	Organic Chemistry Lab (2)
Chem 90	Physical Chemistry (3)
Chem 191	Physical Chemistry (3)
Chem 234	Analytical Chemistry Lab (1)
Chem 310	Instrumentation (3)
Chem 332	Analytical Chemistry (3)

Recommended Sequence of Courses

Freshman Year, First Semester (15 credit hours)

Math 21	Analytic Geometry and Calculus I (4)
Chem 21, 22	Introductory Chemical Principles & Lab (5)
Engl 1	Composition and Literature (3)
	General Elective (3)

Freshman Year, Second Semester (14 credit hours)

Math 22	Analytic Geometry and Calculus II (4)
Geol 1, 2	Principles of Geology and Lab (4)
Engl 2, 10, 14, or 16	Composition and Literature (3)
	General Elective (3)

Sophomore Year, First Semester (16 credit hours)

Math 23	Analytical Geometry (4)
Phys 11, 12	Introductory Physics I and Lab (5)
Biol 1, 2	Principles of Biology and Lab (4)
Geol 211	Environmental Geology (3)

Sophomore Year, Second Semester (14 credit hours)

Physics 21, 22	Introductory Physics II and Lab (5)
Geol 12	Historical Geology and Stratigraphy (3)
Biol 35	Microbiology (3)
	General Elective (3)

Junior Year, First Semester (16 credit hours)

Chem 51, 53	Organic Chemistry and Lab (4)
Eco 311	Environmental Economics (3)
	Concentration Courses (6)
	General Elective (3)

Junior Year, Second Semester (15 credit hours)

Chem 23	Analytical Environmental Chemistry (3)
Biol 306	Ecology (3)
	Concentration Course (3)
	General Electives (6)

Senior Year, First Semester (15 credit hours)

Biol 331	Evolution of Nonvascular Plants or
Biol 303	Invertebrate Zoology (3)
Geol 33	Introductory Mineralogy and Petrology (3)
	Concentration Course (3)
	General Electives (6)

Senior Year, Second Semester (15 credit hours)

CE 371	Environmental Health Engineering (3)
	Concentration Courses (6)
	General Electives (6)

Fine Arts

Professor

Richard J. Redd, M.F.A., *Chairman*

Associate Professor

Carlos J. Alvare, M. Arch., M.C.P.

Assistant Professor (Visiting)

Tom Althouse, M.F.A.

Instructors

Gary M. Burnley, M.F.A.
Rita M. Strasburger, M.A.
Ricardo Viera, M.F.A.
Victor Caliandro (Visiting), B. Arch.

The Department of Fine Arts offers three major programs designed to develop the creative potential of the individual both on a personal and social level and to provide a foundation for graduate studies in fine arts.

The program for general art offers the student experience in drawing, painting, printmaking and sculpture which will nurture creative expression and growth as the artistic skills develop.

The program in pre-architecture focuses on urban concerns, both functional and aesthetic, which deal with problems of man, society and space. At least two years of additional study beyond the B.A. at Lehigh are necessary to complete an architectural program.

The art history program gives the student a foundation in the evolution of European art from ancient to modern times and is designed for those who wish to pursue this area of the humanities as a professional art historian. It is strongly advised that the student planning to major in art history have three years of a foreign language at the college level.

The resources of a growing Lehigh University art collection, scheduled art exhibitions, field work and contact with area architects and planners, extend the art programs into campus and community. Several major museums within easy traveling distance facilitate the firsthand study of art. Art history students will do research in the art collection of the University.

Cooperation with nearby Moravian College and other colleges of the Lehigh Valley Association of Independent Colleges allows students to register for art courses in ceramics, sculpture, photography, etc. not offered at Lehigh.

General Art Major (42 credit hours)

Certain studio courses with limited space, i.e., F.A. 10, 11, 12, 13, and 20, are restricted in enrollment and require consent of the chairman.

Required Preliminary Courses (15 credit hours)

FA 5	Introduction to the Visual Arts (3)
FA 10	Design or F.A. 20 Color (3)
FA 11	Basic Drawing (3)
FA 12	Three-Dimensional Design (3)
	or one other 3-D course
FA 23	Life Drawing (3)

Required Major Courses (27 credit hours)

FA 220	20th-Century Art (3)
Art History	Any two courses (6)
Art Studio	Six courses, two at the advanced level (18)

Pre-Architecture Major (55 credit hours)

Required Preliminary Courses (22 credit hours)

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Phys 11	Introductory Physics (4)
Phys 12	Introductory Physics Lab (1)
FA 3, 4	History of Architecture (6)
FA 13	Architectural Drawing (3)

Required Major Courses (33 credit hours)

Mech 1	Statics (3)
Mech 11	Mechanics of Materials (3)
CE 159	Structural Analysis I (3)
CE 160	Structural Design (3)
FA 43	Environmental Design (3)
FA 143	Environmental Planning and Project (3)
FA 144	Intermediate Environmental Design (3)
FA 244	Architectural Design (6)
FA 200	20th-Century Architecture (3)
FA 151	History of Urban Design (3)

Art History Major (36 credit hours required)

Required Preliminary Course

FA 5	Introduction to the Visual Arts (3)

Required Major Courses

	One of the following:
FA 10	Design (3)
FA 11	Basic Drawing (3)
FA 23	Life Drawing (3)
Art 75	Ceramics I (Moravian) (4)
	One of the following:
Gk 201	Archaeology of the Near East (3)
Gk 202	Archaeology of Greece (3)
Lat 203	Archaeology of Italy (3)
	Nine of the following, at least four at the 200 level, for 27 credit hours:
FA 3	History of Architecture I (3)
FA 4	History of Architecture II (3)
FA 102	Ancient Art (3)
FA 113	Medieval Art (3)
FA 115	Italian Renaissance Art (3)
FA 117	Baroque and Rococo Art (3)
FA 200	20th Century Architecture (3)
FA 219	19th Century Painting (3)
FA 220	20th Century Art (3)
FA 271	Readings (3)

Collateral courses are recommended, and in some instances may be substituted for the above in civil engineering, geology, government and social relations. For examples: S.R. 368; C.E. 13; Govt. 357; Geol. 211.

Undergraduate Courses

3. History of Architecture I (3) P fall
A study of man's expression through architecture from the prehistoric through the Romanesque period. Conditioning influences, evolution of styles, the development of organic and inorganic types, in relation to structural purposes, and social expression. Ms. Strasburger.

4. History of Architecture II (3) P spring
Factors determining the development and spread of Gothic, Renaissance, and succeeding styles, the effects of discovery and exploration, the rise of romantic, classic, functional, international, and contemporary movements are examined as epochal expression. Principles of appreciation and aesthetic character in the scientific age. Ms. Strasburger.

5. Introduction to the Visual Arts (3) P fall
An introduction to principles of visual expression. Examples of art from various periods are examined in relation to their historical and cultural context, to their plastic organization and their significance as reflection of human experience.

10. Design (3) PU fall
Principles of design and composition in two dimensions. Basic color theory. Individual and group projects directed towards developing visual awareness. Prerequisite: consent of department chairman. Mr. Burnley.

11. Basic Drawing (3) PU fall-spring
Introduction to the concepts and practice of building and representing three-dimensional form. Methods and media of drawing. Prerequisite: consent of department chairman. Mr. Burnley.

12. Three-Dimensional Design (3) PU alternate years
Individual and group projects directed toward developing design in three dimensions. Exploration of materials and their application. Prerequisite: consent of department chairman. Mr. Burnley.

20. Color (3) PU alternate years
Projects directed toward building an awareness of color. Study and observation of the dynamics of color in theory and practice. Prerequisite: consent of chairman. Mr. Burnley.

23. Life Drawing (3) PU
Drawing from the live model as the fundamental experience

towards building form. Prerequisite: consent of the chairman. Mr. Burnley.

33. Painting (3) fall-spring
An introduction to painting in oil, acrylic or watercolor oriented toward developing individual creative expression combined with an understanding of the physical nature of the materials. Studio prerequisite: F.A. 10 or 11, or consent of the chairman. Mr. Redd.

37. Introduction to Printmaking (3) fall
A structured course in mono print, relief "block" printing and basic etching. Introducing materials and tools, stressing creative application and the conceptual aspects of the media. Prerequisite: F.A. 11, Mr. Viera.

38. Intaglio Printmaking (3) spring
Introduction to etching, engraving, drypoint, and aquatint. Investigation of plate surfaces, inks, grounds, acids and papers. Prerequisite: F.A. 11 or consent of the chairman. Mr. Viera.

43. Environmental Design (3)
Basic architectural design. Function, selection and organization of spaces. Study of light, color and texture. Emphasis on creative concepts in consideration of total environment. Critiques and open juries. Prerequisite: F.A. 13 or CE 11, field experience or consent of chairman. Mr. Alvare.

75. Ceramics I (3)
Elementary problems in the basic techniques of hand-built and wheel-thrown pottery. Moravian College campus.

102. (Greek 102) Ancient Art (3) PU spring
A history of the visual arts in the ancient world from prehistoric to the period of Constantine the Great. Correlation with political, social, and literary background of each culture. Ms. Strasburger.

113. Medieval Art (3) PU
A study of architecture, painting, sculpture and the minor arts from the fall of Rome through the 14th century in Western Europe and the Byzantine Empire. Ms. Strasburger.

115. Italian Renaissance Art (3) PU every third year in fall
Painting and sculpture are examined as the outgrowth of conditions in Italy during the fourteenth, fifteenth, and sixteenth centuries: the influence of medieval thought and tradition, the awakening interest in nature, the effect of antiquity, especially the stimulus it gave to the individual effort. Mr. Redd.

117. Baroque and Rococo Art (3) PU
The artistic environment of Europe from the Counter-Reformation to the French Revolution as illuminated by examples of painting, sculpture and architecture provides foundations for better comprehension of artistic principles. Historical, aesthetic and technical aspects of the art as basis for appreciation. Ms. Strasburger.

123. Advanced Life Drawing (3)
An advanced course in drawing from the live model. Prerequisite: F.A. 23. May be repeated for credit. Mr. Burnley.

133. Intermediate Painting (3) fall-spring
Problems in oil, watercolor, acrylic and mixed media. Prerequisite: F.A. 33. Mr. Redd.

143. Environmental Planning and Project (3) fall-spring
Concentrated environmental design projects. Individual and team planning. Investigatory and cumulation procedures and problems. Content tailored to contemporary needs and student requirements–conferences, critiques. Closed juries. For majors only. May be repeated for credit. Mr. Alvare.

144. Intermediate Environmental Design (3) fall-spring
More advanced study in architecture and site design. Increase in scope and complexity of projects. Critiques and open juries. Prerequisite: F.A. 43 or consent of department chairman. Mr. Alvare.

145. Structure in Architecture (3) fall
Introduction to structural forms and systems; directed toward an understanding of various structural elements. Vocabulary of structural terms. Prerequisite: consent of department chairman or Mech. 1. Mr. Caliandro.

151. History of Urban Design (3) fall
The historical development of urban design in the evolution of the city. City planning theories. Special emphasis will be given to the social and economic parameters which determine physical design. Study of the methods and practices used in the United States today. Seminar course. Prerequisite: F.A. 43 or consent of chairman. Mr. Alvare.

152. Physical Planning and Design (3) spring
Solution of a physical planning problem with special emphasis on the relationship between the design functions and the social, economic and political programs under which the plan will develop. Studio course. Prerequisite: F.A. 151. Mr. Alvare.

175. Ceramics II (4)
Problems in wheel-throwing construction and decoration. Emphasis on creative expression and experimentation. Prerequisite: F.A. 75. Moravian College campus.

176. Ceramics III (4)
Individual problems in thrown and hand-built pottery. May be repeated for credit. Prerequisite: F.A. 175. Moravian College campus.

180. Photography I (4)
Fundamentals of photography are explored and particular attention is given to the study of metaphor and symbol, photographic technique, and photography as an art form. Moravian College campus.

181. Photography II (4)
Exploration of photography with emphasis on individual

expression and advanced technique. Prerequisite: F.A. 180. Moravian College campus.

200. 20th Century Architecture (3) spring
History and theory of modern architecture from late 19th century antecedents. Wright, LeCorbusier, and Mies van der Rohe, and major 20th century schools of architectural design. Ms. Strasburger.

211. Advanced Drawing (3) fall-spring
Projects in creative drawing designed to build on concepts and practices initiated in basic drawing and life drawing. May be repeated for credit. Prerequisite: F.A. 11 and 23. Mr. Burnley.

213. Sculpture II (3)
Individual problems in a variety of three-dimensional media. May be repeated for credit. Moravian College campus.

219. 19th Century Painting (3) fall, alternate years
From Neoclassicism through the sequential movements of Romanticism, Naturalism, Impressionism, and Post-Impressionism in the art of Europe and the U.S. Mr. Redd.

220. 20th Century Art (3) spring
Sequential movements in contemporary painting and sculpture. Their interrelations as cultural expression. Museum reports and critical interpretation. Mr. Redd.

233. Advanced Painting (3) fall-spring
Provides creative work in depth in a variety of painting media. Prerequisite: F.A. 133 or consent of chairman. May be repeated for credit. Mr. Redd.

237. Intermediate Printmaking (3) fall-spring
Introduction to aluminum plate lithography and basic serigraphy. Further exploration in relief and intaglio printing. Survey of special topics, reading in the history of printmaking, problems in edition printing and today's print market. Prerequisite: F.A. 37 or 38. Mr. Viera.

244. Architectural Design (1-3) fall-spring
Individual study, project or other assignment for advanced students or majors capable of progress beyond general course content or requirement. Content organized by instructor and chairman of department. Conferences and critiques. May be repeated for credit. Prerequisite: consent of department chairman. Mr. Alvare.

271. Readings (3) fall-spring
Readings in the visual arts for students who wish to pursue special interests in art history, art criticism or aesthetics not covered by the regular course offerings. Prerequisite: consent of department chairman.

273. Special Topics in Studio Practice (1-4) fall-spring
Individually directed projects for advanced students capable of undertaking independent creative work in applied art. Prerequisite: consent of department chairman.

333. Media in Painting (3)
A painting course which focuses on historical techniques. Studio practice preparing and working in 15th and 16th century media. Reading on media and materials. Prerequisite: consent of chairman. Mr. Redd.

337. Printmaking Workshop (3) fall-spring
Independent experimentation and work in chosen graphic media for the advanced student. Photographic applications, conceptual problems and mixed media. Conferences and critiques. May be repeated for credit. Prerequisite: F.A. 237 or consent of chairman. Mr. Viera.

Five-Year Programs

Other program combinations leading to two degrees can be found under Arts-Engineering sequences or may be developed by consulting Graduate School requirements and the chairman of the appropriate department.

Electrical Engineering and Engineering Physics

This curriculum is particularly well suited for students seeking thorough preparation in the field of physical electronics. The program adds to the basic electrical engineering curriculum a sequence of upper-level undergraduate physics courses.

The electrical engineering degree is conferred on the completion of the fourth year, and the engineering physics degree at the end of the fifth year.

Freshman Year (See page 52)

Sophomore Year, First Semester (16 credit hours)

EE 11	Introduction to Computer Engineering (3)
Math 23	Analytical Geometry & Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
Eco 1	Economics (4)

Sophomore Year, Second Semester (17 credit hours)

EE 20	Introduction to Circuit Theory (4)
Math 205	Linear Methods (3)
Phys 31	Introduction to Quantum Mechanics (3)
Mech 103	Principles of Mechanics (4)
	GS Requirement (3)

Junior Year, First Semester (14-17 credit hours)

EE 104	Linear Systems & Signals (4)
EE 105	Electronic Circuits (4)
Math 231	Probability and Statistics or
Math 309	Theory of Probability (3)
	GS Requirement (3)
	Elective (0-3)*

Junior Year, Second Semester (17 credit hours)

EE 103	Physical Electronics (3)
EE 106	Electromechanics & Machines (3)
EE 231	Electric and Magnetic Fields or
Phys 212	Electricity and Magnetism I (3)
EE 142	Junior Lab (2)
	Approved Elective (3)
	Elective (3)

Summer

EE 100	Industrial Employment

Senior Year, First Semester (15-18 credit hours)

EE 11	Proseminar (1)
EE 151	Senior Lab I (2)
EE 245	Electromagnetic Theory or
Phys 213	Electricity and Magnetism II (3)
Phys 215	Particles & Fields I (3)
EE	Departmental Electives (3)
	GS Requirement (3)
	Elective (0-3)*

*Please refer to description of normal programs, page 52.

Senior Year, Second Semester (18 credit hours)

Phys 216	Particles & Fields II (3)
EE	Departmental Electives (9)
	GS Requirement (3)
	Elective (3)

Fifth Year, First Semester (17 credit hours)

Phys 192	Advanced Lab (2)
Phys 340	Thermal Physics (3)
Phys 362	Atomic and Molecular Structure (3)
Math 322	Methods of Applied Analysis I (3)
	Approved Elective (3)
	Elective (3)

Fifth Year, Second Semester (15 credit hours)

Phys 254	Optics Lab (2)
Phys 363	Physics of Solids (3)
Phys 171	Proseminar (1)
	Approved Elective (3)
	Electives (6)

Note: Approved electives are two courses selected from Phys. 364, 365, 369; Mech. 302.

Engineering-M.B.A. Program

This program is designed to meet the needs of competent students in any of the engineering curricula who wish to add to their engineering studies training in business management at an advanced level.

The time involved is five years, but a summer session would be necessary to attain both a bachelor's degree in engineering and a master's degree in business administration or management science. In addition to a course in economics, which is required of all engineering undergraduates, thirty hours of basic business courses are necessary to meet the background requirements for the M.B.A. degree. If as much as eighteen hours of such courses can be rostered in the student's engineering curriculum, the remaining twelve hours can be obtained in one summer. Otherwise, attendance at an additional summer session would be necessary. Candidates for each program will be required to take the Admission Test for Graduate Study in Business.

For background courses required for the M.B.A., engineering students should see the section of graduate study in business and economics, and consult with Max D. Snider, associate dean of the college.

Arts-M.B.A. Program

This program is designed to meet the needs of students in the College of Arts and Science who wish to add to their arts studies training in business management at an advanced level.

The time involved in the program is five years, but a certain amount of summer session work may be necessary for majors in the sciences to attain both a bachelor of arts and a master's degree in business administration within that period. In addition to one course in economics, which can be counted as part of the social science distribution requirements, thirty hours of basic business courses are needed to meet the background requirements. Thirty hours of requirements for the master of business administration degree must also be completed.

For background courses for the M.B.A., students should see graduate study in business and economics, and consult with Max D. Snider, associate dean of the college. Many of the background courses can be rostered in the student's arts curriculum.

B.S. in Engineering, Master's in Materials

Sophisticated designs of modern systems depend to a major extent upon an appreciation of the world of materials. Judicious selection of materials in design, as well as the design of materials *per se*, requires a depth of understanding which can seldom be achieved in typical undergraduate programs. Especially for the chemical, civil, electrical and mechanical engineer, the bachelor of science in engineering-master's in materials program provides a means of developing this depth of understanding.

Undergraduates in the various branches of engineering interested in such a program can qualify for the master of science in materials program by careful selection of their technical electives. Students can thus augment the scope of

the four-year B.S. program in a traditional engineering branch with an understanding of materials behavior gained in a graduate program.

Whereas this combined five-year program is intended for those entering industry, it provides sufficient flexibility to enable those interested in materials research and/or development to continue toward the Ph.D. degree.

Undergraduates interested in the opportunities offered by the program should consult their departmental advisors and also the chairman of the Department of Metallurgy and Materials Science. To ensure satisfactory completion of prerequisites, such consultation should precede the beginning of the junior year. Examples of typical prerequisite patterns and programs are available in the Department of Metallurgy and Materials Science.

Foreign Careers

Finn B. Jensen, *Chairman of Economics, Director of the Foreign Careers Program*

Major in Arts and Science College

The interdepartmental major in foreign careers is designed to give students the grounding in language, history, economics, and related subjects needed for successful work with private industry or governmental agencies in their overseas activities.

Each student in the program will schedule all courses in the common core and in one of the options. In addition, he or she will, in consultation with the director, select courses in language, history, and other subjects which will provide an intensive knowledge of the culture of the area in which the student is interested. Students electing the Russian area option will be expected to study Russian.

The program also affords a broad base for graduate study in social sciences and business administration. Students interested in this aspect of the major sequence should consult the director early in their college careers.

Common Core

Required Preliminary Courses

Eco 1	Economics (4)
Govt 3	Comparative Politics (3)
Math 21	Analytic Geometry and Calculus I (4) or
Math 41	BMSS Calculus I (3)
Eco 45	Statistical Method (3)

	Concentration in the Latin American area
Eco 305	Economic Development of Latin America (3)
SR 367	Latin American Social Institutions (3)
Hist	Six hours of Latin American History (6)
	Concentration in the European area
Eco 309	Comparative Economic Systems (3)
Eco 343	European Economic Integration or
I.R. 101	The Politics of European Integration (3)
Hist	Six hours of European History (6)
	Concentration in the Russian area
Eco 309	Comparative Economic Systems (3)
Govt 362	The Soviet System of Government (3)
IR 133, 134	Diplomacy of Russia (6)
IR 334	The Soviet Union in World Affairs (3)

Foreign Trade Option

Acctg 51	Essentials of Accounting or
Acctg 108	Fundamentals of Accounting (3)
Eco 129	Money and Banking (3)
Eco 339, 340	International Trade & Finance (6)
Eco	In consultation with the advisor (6)

Public Administration Option

Acctg 51	Essentials of Accounting or
Acctg 108	Fundamentals of Accounting (3)
IR 352	International Organization or
IR 361	International Law (3)
Eco 353	Public Finance (3)
Govt 360	Public Administration (3)
Govt 363	Contemporary Political Philosophy or
Govt 364	Contemporary Political Analysis (3)
Govt 361	Comparative Administrative Systems (3)
Govt 322	Developing Countries (3)

Open Option

In place of any of the three preceding options, a student may take an open option by meeting the advanced course requirements for one of the other arts college majors. The open option is most feasible with humanities and social science majors but will require a careful combining of distribution courses and free electives with the eighteen hours normally given to the option. Students interested in the open option should consult the director of the Foreign Careers major as early as possible.

Fundamental Sciences

Robert T. Gallagher, *Associate Dean of the College of Engineering and Physical Sciences, Director of Fundamental Sciences Program.*

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, about 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, or approach adequacy for graduate study in a field.

Fundamental science students are required to concentrate in a major or in a hybrid of two fields. 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 of these.

The program offers excellent opportunity for students who are uncertain of their desire for a career in a particular field to proceed on a broad program which can lead to a bachelor's degree. If the student's interest crystallizes in an established field, transfer to that major will normally be possible with only a minimum of dislocation, especially if the student has completed the introductory courses in that field.

Work in the major field is continuous through all four years. The freshman year is identical with that of all students in the College. The general studies (GS) requirements of the college must also be satisfied. The discipline of a field will be provided by the inclusion of at least 15 semester hours or from a combination which constitutes the core of one of the hybrid fields, for example, geophysics or biochemistry. Likewise, programs in applied mathematics can be organized to contain courses in mathematics along with upper-level courses in a physical science. Programs in computing science are designed to include courses in computer languages and programming, information science and computer architecture. Students pursuing concentrations in these two areas may, with the approval of their advisor, 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 will be worked out by the student with the advice of the curriculum advisor, and with the approval of the department chairmen concerned with the fields of concentration.

Freshman Year *(See page 52)*

Sophomore Year, First Semester (15-16 credit hours)

Biol 21, 22	Principles of Biology and Lab (4) or
Geol 1	Principles of Geology (3)
Chem 51, 53	Organic Chemistry and Lab (4)
Math 23	Analytical Geometry and Calculus III (4)
Eco 1	Economics (4)

Sophomore Year, Second Semester (17 credit hours)

	Major (3)
	Approved Elective (3)
Math 205	Linear Methods (3)
Phys 21, 22	Introductory Physics II & Lab (5)
	GS Elective (3)

Junior Year, First Semester (15-16 credit hours)

Geol 1	Principles of Geology (3) or
Biol 21, 22	Principles of Biology and Lab (4)
Psych 3	Psychology as a Natural Science (3)
Math 231	Probability and Statistics (3)
	Major (3)
	GS Elective (3)

Junior Year, Second Semester (15 credit hours)

Approved Electives (6)
Major (6)
Elective (3)

Senior Year, First Semester (15-18 credit hours)

Approved Electives (6)
Major (6)
GS Elective (3)
Elective (0-3)*

Senior Year, Second Semester (15-18 credit hours)

Phil 42	The Scientific Process (3)
	Approved Elective (3)
	Major (6)
	GS Elective (3)
	Elective (0-3)*

*Please refer to description of normal programs, page 52.

Geological Sciences

Professors

J. Donald Ryan, Ph.D., *Chairman*
James M. Parks, Ph.D., *Director, Center for Marine and Environmental Studies*
Adrian F. Richards, Ph.D.
Charles B. Sclar, Ph.D.
Dale R. Simpson, Ph.D.

Associate Professor

Paul B. Myers, Jr., Ph.D.

Assistant Professors

Bobb Carson, Ph.D.
Edward B. Evenson, Ph.D.
Richard L. Stocker, Ph.D.
John R. Sumner, Ph.D.

Geology, and related sciences such as geophysics and geochemistry, deal with natural phenomena on or within the earth. Each is a science which makes use of other more fundamental sciences in its practice; hence, the student preparing for a career in one of the geological sciences must combine study in geology with a broad understanding of physical, chemical, and biological principles.

Lehigh offers two undergraduate programs in geological science, one leading to the degree of B.S. in geological sciences, the other to the degree of B.A. The B.A. program requires fewer credits for graduation (120 vs. 126 credit hours), fewer courses in collateral sciences and mathematics (34 vs. 37 credit hours), and fewer geology courses (31 vs. 38 credit hours). Candidates for the B.S. degree are also required to take 15 credit hours in approved professional electives. The professional electives permit the student to arrange for an informal option in an area such as geophysics, geochemistry, engineering geology, etc.

Students electing the B.A. program are required to meet the distribution requirements of the College of Arts and Science; candidates for the B.S. degree take 30 credit hours of nonprofessional electives in place of the distribution requirements. There is no foreign language requirement in either program. However, it is strongly recommended that all students planning on attending graduate school, who have not previously studied either French, German or Russian, should include courses in one of these languages in their undergraduate programs.

Attendance at an approved summer geology field camp is required in both programs.

Both the B.S. program and the B.A. program provide preparation for graduate school. 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 (M.S. or Ph.D.) during the senior year. Students enrolled in this program often will be able to complete all requirements for the M.S. degree with only one year of study beyond the baccalaureate.

Geological training may be utilized in industry (especially in the petroleum, mining, highway construction, ceramics, and metallurgical industries), government service, natural resource management, and in secondary school and college teaching. Students planning on careers in industry are advised to register for the B.S. program.

B.S. in Geological Sciences (126 credit hours)

College and University Requirements (36 credit hours)

Engl 1	Composition and Literature (3)
Engl 2, 10, 14, or 16	Composition and Literature (3)
	Electives (30 credit hours)

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. The elective program includes a large number of courses broadly distributed among the various areas of the humanities and the social sciences.

The Major Program (90 credit hours)

Mathematics (12 credit hours)

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Math 23	Analytic Geometry and Calculus III (4)

Collateral Sciences (22 credit hours)

Chem 21, 22	Introductory Chemical Principles and Lab (5)
Chem 31	Chemical Equilibria in Aqueous Systems (3)
Phys 11, 12	Introductory Physics I and Lab (5)
Phys 21, 22	Introductory Physics II and Lab (5)
Biol 21, 22	Principles of Biology and Lab (4)

Geology (41 credit hours)

Geol 1	Principles of Geology (3)
Geol 10	Computer Applications (1)
Geol 12	Historical Geology (3)
Geol 23	Structural Geology (3)
Geol 33	Introductory Mineralogy and Petrology (3)
Geol 297	Geological Thermodynamics (3)
Geol 301	Introduction to Geophysics (3)
Geol 311	Paleontology (3)
Geol 313	Sedimentology (3)
Geol 333	Crystallography (3)
Geol 334	Petrology and Petrography (4)
Geol 336	Mineral Phase Relations (3)
	Field Camp (6)

Approved Professional Electives (15 credit hours)

Courses approved to fulfill this requirement should form a coherent package supporting the professional objectives of the student.

B.A. with Geology Major (120 credit hours)

College and University Requirements

Engl 1 Composition and Literature (3)
Engl 2, 10, 14 or 16 Composition and Literature (3)
Distribution Requirements (See page 41.)

The Major Program (65 credit hours)

Mathematics (12 credit hours)

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Math 23	Analytic Geometry and Calculus III (4)

Collateral Sciences (22 credit hours)

Chem 21, 22	Introductory Chemical Principles and Lab (5)
Chem	Approved elective (3)
Phys 11, 12	Introductory Physics I and Lab (5)
Phys 21, 22	Introductory Physics II and Lab (5)
Biol 21, 22	Principles of Biology and Lab (4)

Geology (31 credit hours)

Geol 1	Principles of Geology (3)
Geol 10	Computer Applications (1)
Geol 12	Historical Geology (3)
Geol 23	Structural Geology (3)
Geol 33	Introductory Mineralogy and Petrology (3)
Geol	Approved electives (12)
	Field Camp (6)

Combined B.A. or B.S. and M.S. Program in Geological Sciences

The department of geological sciences offers a combined B.A. or B.S. and M.S. program in geological sciences. Students working toward the B.A. in geology or the B.S. in geological sciences who are enrolled in this program are permitted to take courses which apply toward the M.S. degree during their senior year. Usually this will permit completion of the M.S. program within one year (or less) of receiving the bachelor's degree. During the student's senior year, the normal undergraduate tuition will cover the costs of all courses taken including those which are taken for graduate credit. After receiving the bachelor's degree, students registered in the program who have done satisfactory work may acquire upon admission to the graduate school full-time graduate status, and as such, they will become eligible to apply for appointment to a teaching assistantship, 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 30 credit hours to complete work for the bachelor's degree. Students accepted into the program generally also must rank in the upper half of their class and must have at least a "B" average in all geology courses completed.

Application for admission to the program should be made during the spring semester of the junior year (generally at the time of preregistration or later) and must be approved by the department faculty and the Dean of the Graduate School. The application must include (1) a tentative M.S. program approved by the department chairman, and (2) a roster, also approved by the department chairman showing which courses taken during the senior year apply toward the bachelor's degree and which courses apply toward the master's degree. No more than 15 credit hours per semester may be rostered. A total of 150 credit hours is required for the combined B.A.-M.S. program and a total of 156 credit hours is required for the combined B.S.-M.S. program. All of the normal requirements for each degree as outlined in the catalog must be fulfilled.

Students enrolled in the program should make application for admission to full-time graduate status after completing the first semester of the senior year.

Undergraduate Courses

1. Principles of Geology (3) fall-spring
Fundamental concepts of geology; the composition, structure, and development of the earth; processes of geological change. Lectures, laboratory work, and field trip.

2. Introductory Geology Laboratory (1) fall-spring
Laboratory to be taken concurrently with Geol. 1. Study of rocks and minerals, rock structures, land forms. Prerequisite: Geol. 1 previously or concurrently.

10. Computer Applications (1) fall
The use of computers in the solution of geological problems. Introduction to FORTRAN; the use of published and available programs. Mr. Parks.

12. Historical Geology and Stratigraphy (3)
Origin and evolution of the earth and its parts: continents, ocean basins, hydrosphere, and atmosphere; origin and evolution of life. Stratigraphic correlation, facies change, breaks in the record, paleogeographic and paleoenvironmental reconstruction. Prerequisite: Geol. 1. Mr. Ryan.

23. Structural Geology (3) spring
The application of basic concepts of stress and strain and experimental data to study of the developments of faults, folds, and other deformational structures in the earth's crust. Introduction to the larger scale problems of geotectonics. Prerequisite: Geol. 1. Mr. Myers.

33. Introductory Mineralogy and Petrology (3) fall
Principles of crystallography, mineralogy, and petrology; megascopic study, identification, and description of common minerals and rocks. Lectures and laboratory. Prerequisites: Geol. 1, Chem. 21. Mr. Sclar.

63. Introduction to Oceanography (3) spring
A survey of the physical, chemical, biological, and geological

nature of the oceans. Two lectures, one recitation. Prerequisite: one year of science (biology, chemistry, geology or physics). Messrs. Richards and Carson.

101. Geology for Engineering (3) fall
A study of the materials which 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-recitation. Mr. Myers.

For Advanced Undergraduates and Graduates

201. Earth Sciences I—Geology (3) summer
Fundamental concepts of geology; composition and structure of the earth, dynamics of natural processes, evolution and development of the earth. Must be taken concurrently with Geol. 203. Designed for secondary school science teachers. Prerequisites: graduate standing or consent of department chairman.

203. Geology Workshop (3) summer
Field and laboratory exercises in geology. Must be taken concurrently with Geol. 201.

211. Environmental Geology (3) fall
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. Lectures, discussions, and occasional field trips. Mr. Evenson.

281. Geological Research (1-6) fall
Independent investigation of a special problem in the field, laboratory, or library. Prerequisite: consent of department chairman.

282. Geological Research (1-6) spring
Similar to Geol. 281. May be elected as a continuation or separately. Prerequisite: consent of department chairman.

301. Introduction to Geophysics (3) fall
The application of the principles and practices of physics to the solution of problems related to the earth. The origin of the earth; geochronology; temperature of the earth; seismology, gravitation; geomagnetism, terrestrial electricity. Prerequisite: senior standing or consent of department chairman. Mr. Sumner.

304. Topics in Geophysics (3)
The application of seismic, electrical, magnetic, and gravity measurements to the solution of problems in crustal geology and exploration. Includes field exercises. Prerequisite: Geol. 301. Mr. Sumner.

306. Geophysical Field Techniques (3) spring
Geophysical field investigation in an area of geological interest. Theory and application of seismic, gravity, magnetic, and electrical methods; data collection, interpretation, and a written report. Individual assignments of a geophysical field in an area of geological interest. Prerequisite: Geol. 301 or consent of department chairman. Mr. Sumner.

307. Basic Processes and Material Properties I (3) fall
The modeling of geological-geophysical phenomena in terms of the interaction of basic mechanical, thermal, and chemical processes. Thermodynamic and transport material properties required to formulate such models; composite media theory; selected boundary value problems to illustrate the fundamental macroscopic characteristics of the basic processes. Mr. Stocker.

308. Basic Processes and Material Properties II (3) spring
Continuation of Geol. 307. Prerequisite: Geol. 307. Mr. Stocker.

311. Paleontology (3) spring
Morphology of invertebrate fossils, their use in interpreting geologic history; evolution of the faunas and floras. Lectures and laboratory work. Prerequisite: Biol. 21. Mr. Parks.

312. Geomorphology (3) spring
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 field trips. Prerequisite: introductory course in geology. Mr. Evenson.

313. Sedimentology (3)
The processes that control weathering, transportation, and deposition of sediments; the characteristics of sediments and environments of deposition. Lectures and laboratory. Prerequisite: Geol. 333.

314. Glacial and Quaternary Geology (3) spring
Study of the origin, distribution, and movement of present and past glaciers. Special emphasis on glacial land forms and deposits, quaternary stratigraphy and absolute dating techniques, periglacial phenomena, and Pleistocene environments. Lectures and required field trips. Prerequisite: Geol. 1. Mr. Evenson.

315. Coastal Sedimentation (1)
Origin, dispersal, and deposition of clastic sediments in the shore zone with emphasis on the barrier beach-salt marsh complex. Lectures and laboratory conducted at Wetlands Institute. Not offered on regular basis. Prerequisite: consent of department chairman.

317. (Biol. 317) Evolution (3)
For course description see Biology 317.

319. Regional Stratigraphy (2) spring
Studies of sedimentary rock sequences in North America illustrating principles of correlation, facies change, methods of environmental and paleogeographic reconstruction. Mr. Ryan.

320. Advanced Computer Applications (1-3)
Independent investigation of special problems utilizing computer techniques. Prerequisite: Geol. 10 or consent of department chairman. Mr. Parks.

321. Statistical Applications (3) spring
Statistical models applicable to geological, geophysical, and geochemical field and laboratory studies. Analysis of variance, applications of the chi-square distribution, analysis of covariance, linear, non-linear and multiple regression, and distribution-free methods. Mr. Carson.

333. Crystallography (3) fall
Fundamentals of crystallography and crystal structure; patterns and symmetries, symmetry notations, crystal morphologies and internal structure, principles of crystal chemistry. The anisotropy of crystalline materials with special reference to crystal optics. Lectures and laboratory. Prerequisite: Chem. 21. Mr. Simpson.

334. Petrology and Petrography (4) fall
Evolution of crystalline rocks and their distribution in space and time; physical and chemical factors in igneous and metamorphic processes. Microscopic study of rocks. Lectures, laboratory work, and field trips. Prerequisite: Geol. 333. Mr. Myers.

336. Mineral Phase Relations (3) spring
Principles of phase equilibria; unicomponent and multicomponent condensed systems and multicomponent systems with volatile phases. The application of phase relation studies to mineralogical and geological problems. Prerequisites: Chem. 21, Geol. 333. Lectures and laboratory. Mr. Simpson.

337. (Met. 333) X-ray Methods (3)
For description, see Met. 333.

338. (Met. 334) Electron Metallography (3)
For description, see Met. 334.

351. Petroleum Geology (3)
Origin, migration, and accumulation of petroleum and natural gas; general principles of exploration and production. Prerequisites: Geol. 23 and Geol. 313 previously or concurrently. Mr. Parks.

352. Applied Mineralogy (3)
Methods and approaches to the solution of industrial and environmental problems employing modern mineralogical techniques, especially transmitted–and incident-light polarizing microscopy and X-ray powder diffraction. Case histories of interest to geologists, chemists, ceramists, chemical, metallurgical, and mineral engineers, environmental engineers, and materials scientists. Lectures and laboratory. Prerequisite: Geol. 333. Mr. Sclar.

356. Ground Water (3)
The geology and geochemistry of ground water. Techniques used in prospecting for ground water, ground water law, management and conservation, evaluation and planning. Prerequisites: Chem. 21, 22, Geol. 23. Mr. Myers.

357. Economic Geology (3) spring
The formation of mineral deposits and the occurrence and characteristics of deposits of economic importance. Includes metals, non-metals, and fuels. Lectures, laboratory work, and inspection trips. Mr. Simpson.

372. Principles of Geochemistry (3) spring
Synthesis of the geological, chemical, physical, and astronomical observations regarding the geochemical evolution of the earth, its internal constitution, and the physico-chemical processes which modify the crust. Crystal-chemical controls on the abundance and distribution of the chemical elements. Experimental high-pressure studies of geochemical significance. Shock metamorphism as a geochemical process on the surface of the earth, moon, and planets. Mr. Sclar.

381. Meteorology (3) fall
Principles of meteorology: composition of the atmosphere, physics of the air, weather systems, weather instruments and forecasting. Two lectures, one laboratory. Mr. Jenkins.

391. Field Seminar (1) spring
Study of regional geological problems using field methods of analysis. Field trips. Prerequisite: consent of department chairman. Mr. Ryan.

393. Photogeology and Remote Sensing (1) fall
Use of aerial photographs and space imagery to obtain qualitative and quantitative geologic and terrain information. Instrument procedures in compiling data. Interpretation as applied to general field geology, petroleum exploration, ore prospecting, engineering geology, hydrologic studies, land planning. Prerequisite: Geol. 1 or 101. Mr. Ryan.

For Graduates

The graduate program in geology is mainly directed toward the study of geologic processes. Candidates for the master's degree receive instruction in most fields of geology and are expected to take courses in appropriate collateral fields of science. Advanced graduate students, working toward the doctorate, specialize in one field of geology.

Research is an important part of the graduate program. In general, students are encouraged to choose research problems which for their solution require the use of integrated laboratory and field studies.

Candidates for the master's degree are required to take a comprehensive examination during the semester in which they expect to take their degree. The examination also serves as a qualifying examination for admission to candidacy for the doctoral degree. Students entering with the master's degree take the comprehensive examination at the end of their first semester of residence.

Candidates for the Ph.D. degree must demonstrate through examination a thorough reading knowledge of one foreign language, generally French, German, or Russian.

Other requirements for graduate degrees are listed in the

graduate school section of this catalog.

Special departmental research facilities of interest include: Norelco X-ray diffraction unit, Beckman DU spectrophotometer, Beckman infra-red analyzer, Coleman nitrogen analyzer, pH meters, petrographic and binocular microscopes, size analysis equipment for sedimentation studies, chemical balances, hoods, etc., Schmidt-type Askania magnetometer, Worden gravity meter, Gish-Rooney electrical field equipment, standard equipment for geological mapping, Soltzman map projector, furnaces for hydrothermal studies.

402. Electrical Methods (3)
Electrical properties of rocks and minerals; the principles of potential distribution in DC and AC fields. Prerequisites: mathematics through calculus. Mr. Sumner.

404. Seismic Exploration (3)
Theory, field methods, and interpretation techniques in refraction and reflection seismology. Prerequisite: Geol. 301. Mr. Sumner.

405. The Earth's Magnetism (3)
Terrestrial magnetism, rock magnetism, history of the geomagnetic field, spherical harmonics, and the interpretation of magnetic anomalies. Prerequisite: Phys. 21. Mr. Sumner.

407. Origin and Evolution of the Earth (3)
Evolution of the earth on a global scale from its formation to the present. Condensation of the earth from the solar nebula, rate of rotation of the earth, generation of the geomagnetic field, flow in the mantle, etc. Mr. Stocker.

408. Seminar on Geophysics (1)
Critical review and assessment of current literature on major topics in geophysics. May be repeated for credit. Messrs. Stocker and Sumner.

411. Advanced Paleontology (3)
Classification, evolution, biometrics, and paleoecology; study of fossil and modern populations and assemblages. Lectures and laboratories. Prerequisite: Geol. 311. Mr. Parks.

413. Advanced Topics in Sedimentology (1-3)
Study of the origin, dispersal, deposition, and diagenesis of sediments and sedimentary rocks. May be repeated for credit. Schedule of topics published two years in advance. Prerequisite: Geol. 313. Mr. Carson.

417. Sedimentary Petrography (3)
The theory and application of petrographic methods in the study and classification of sedimentary rocks. Prerequisite: Geol. 334. Mr. Ryan.

418. Sedimentary Petrogenesis (3)
The origin and development of sedimentary rock types; mineral provenance, environment of deposition, diagenesis, sediments in time, stratigraphic synthesis. Prerequisite: Geol. 417. Mr. Ryan.

419. Sedimentary Basin Analysis (1)
Seminar on the use of directional features, petrographic variations, and other primary physical properties of sedimentary rock which make possible reconstruction of ancient sedimentary basins and sedimentary dispersal systems within such basins. May be repeated for credit. Mr. Ryan.

421. Global Tectonics (3) fall
Topics include upper mantle composition and configuration, interrelations between the earth's crust and upper mantle, geophysical data related to hypotheses in global tectonics, continental drift and the plate model. Seminars and lectures. Mr. Myers.

422. Regional Tectonics (3) spring
Concepts of global tectonics as applied to the geology of specific areas of the earth's crust. The tectonics of the Alpine-Himalayan chain, Rockies, Caledonides, Appalachian, coast ranges, and African Rift system are among those subjects considered. Seminars and lectures. Prerequisite: consent of department chairman. Mr. Myers.

424. Advanced Structural Geology (3) alternate years
The theory and application of analytical methods in the study of rock deformation; experimental deformation, petrofabric analysis; statistical field methods. Mr. Myers.

435. Advanced Mineralogy (3)
Topics of contemporary interest in mineralogy. Prerequisite: Chem. 302 or equivalent. Mr. Simpson.

436. Advanced Mineralogy (3)
Similar to Geol. 435. Prerequisite: Chem. 302 or equivalent. May be elected separately. Offered as required. Mr. Simpson.

437. Advanced Igneous Petrology (3) alternate years
Origin of the diversity of igneous rocks as revealed by field and laboratory studies. Lectures, laboratory, and field trips. Mr. Sclar.

438. Advanced Metamorphic Petrology (3) alternate years
Processes involved in the transformation of rock masses under high pressure and temperature. Problems of the deep crust and upper mantle. Lectures, laboratory, and field trips. Mr. Sclar.

439. Seminar on Petrology (1)
Critical review and assessment of current literature on major topics in petrology. May be repeated for credit. Mr. Sclar.

454. Genesis of Metalliferous Deposits (3) alternate years
Petrological concepts regarding the origin of metalliferous ore deposits. Laboratory includes ore-mineral synthesis, ore microscopy, and electron microprobe analysis of ores. Field examination of ore deposits at operating mines. Mr. Sclar.

461. Marine Geology (3) alternate years
Geology of the margins and the floors of the oceans. Mr. Carson.

462. Paleoecology (3) alternate years
Reconstruction of paleoenvironments based on principles of paleoecology and sedimentary petrology. Prerequisites: Geol. 311, 313. Mr. Parks.

471. High-Pressure Petrology (3) alternate years
High-pressure phase transformations, phase equilibria, and melting phenomena in multicomponent systems of petrological importance as applied to problems of the deep crust and upper mantle in the pressure range 15 to 150 kilobars at temperatures to 1500 degrees Centigrade. Effect of water as a free phase at high-pressure, and the pressure dependence of ionization phenomena in aquaeous as a free phase at high pressure, and the pressure dependence of ionization phenomena in aquaeous systems. Lectures and laboratories. Mr. Sclar.

472. Solution Geochemistry (3) alternate years
The processes of solution, transport, and deposition under hydrothermal conditions. Mr. Simpson.

480. (Biol. 480) Marine Science Seminar (1)
For description, see Biol. 480. Mr. Carson.

481. Geological Investigation (1-6) fall-spring
Research on a special problem; field, laboratory, or library study; report required. Credit above three hours granted only when a different problem is undertaken.

482. Geological Investigation (1-6) fall-spring
Similar to Geol. 481. Credit above three hours granted only when a different problem is undertaken.

490. Special Topics (1-6)
An extensive study of selected topics not covered in more general courses.

491. Special Topics (1-6)
Similar to Geol. 490. May be elected separately.

Government

Professors

Charles Allan McCoy, Ph.D., *Chairman*
Donald Delyle Barry, Ph.D.
W. Ross Yates, Ph.D.

Associate Professors

Charles N. Brownstein, Ph.D.
Frank Thomas Colon, Ph.D.
Leonard I. Ruchelman, Ph.D.

Assistant Professors

Laura Katz-Olson, Ph.D.
Howard R. Whitcomb, Ph.D.

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. These goals can best be achieved when a student is enabled to assume a large measure of responsibility for his or her own education. The student should be free to study in either structured or unstructured ways. The government department curriculum is designed so that the undergraduate can develop, with the approval of an advisor, a plan of course study in line with his or her interests, concerns and knowledge.

A balanced program within the discipline, one which 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 that the outlined program does not accommodate some students. In that case the students may in consultation with their advisor develop a major program which in their judgment will more adequately fulfill those needs.

The faculty advisor to the student majoring in the government department is designated by the department. The advisor consults with the student and approves his or her major program. The advisor attempts to help the student relate courses offered by the department to the student's educational goals. The advisor also may act as a resource for the student, and may suggest courses in other disciplines, language courses, and courses in research techniques which may be of benefit.

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 in such

positions as governmental official, party or civic leader, public affairs commentator or staff member of a governmental research bureau. Graduate study is advisable for students contemplating certain careers—college teaching, research, or public management, for example.

The following is the major program. Such a program should meet the needs of most students. However, deviations from this program, if requested by the student, may be approved by the advisor.

Core Courses

Govt 1	American Political System (3)
Govt 3	Comparative Politics (3)
Govt 103	Modern Political Philosophy (3)
Govt 321	Methods for Political Research (3)

Electives

Seven elective courses with at least two courses from each of the following two fields:

American Politics—Public Law

Govt 74	Political Parties (3)
Govt 77	Urban Politics (3)
Govt 79	The Politics of Women (3)
Govt 302	Comparative State Politics (3)
Govt 306	Public Policy Process (3)
Govt 317	The American Presidency (3)
Govt 325	Electoral Process (3)
Govt 331	Urban Field Study (3)
Govt 351	Constitutional Law (3)
Govt 352	Civil Rights (3)
Govt 353	Law and Politics (3)
Govt 354	Administrative Law (3)
Govt 357	Technology Assesssment (3)
Govt 358	Community and Regional Politics (3)
Govt 359	The Legislative Process (3)
Govt 360	Public Administration (3)

Political Theory—Comparative Politics

Govt 61	The Soviet Political System (3)
Govt 78	Political Behavior (3)
Govt 308	Classical Political Heritage (3)
Govt 316	American Political Ideas (3)
Govt 318	Communist Political Systems (3)
Govt 322	Politics of Developing Nations (3)
Govt 324	Political Systems in Transition (3)
Govt 363	Contemporary Political Philosophy (3)
Govt 364	Contemporary Political Analysis (3)
Govt 365	Political Values of Neo-Freudians and Existentialists (3)
Govt 368	Political Economy (3)

Urban Studies Option in Government

The government major is eligible to participate in the Urban Studies Program which is a multi-disciplinary focus on the urban process. Interested students should refer to the section on Urban Studies for details.

Government Minor

Shall consist of three of the four core courses listed above (Govt. 1, Govt. 3, Govt. 103, and Govt. 321) plus any two other Government courses.

Undergraduate Courses

1. American Political System (3) P fall-spring
Constitutional principles; organization and operation of the national government; the party system, citizenship, and civil rights.

3. Comparative Politics (3) P fall-spring
The political systems of foreign countries; approaches to the study of comparative politics.

61. The Soviet Political System (3) spring
An examination of the roles of the Communist Party, the Council of Ministers, the Supreme Soviet and other governmental and social organizations in governing the U.S.S.R. Mr. Barry.

74. Political Parties (3) P
Organization, function, behavior and effect of parties on the democratic process. Mr. Brownstein.

77. Urban Politics (3) P spring
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. Mr. Ruchelman.

78. Political Behavior (3) P fall
Behavioral approaches to political science. Application to substantive topics and examples of current research. Mr. Brownstein.

79. The Politics of Women (3) P
Examination of major social and political issues relating to the role of women in American society. Study of other countries will be included for comparative analysis. Ms. Katz-Olson.

103. Modern Political Philosophy (3) fall
Analysis of schools of political thought, including Contract Theorists, Utilitarians, Idealists, and Marxists. Mr. McCoy.

For Advanced Undergraduates and Graduates

302. Comparative State Politics (3) spring
Analysis of major questions relating to the role of the states in the American federal systems and their relationship with the national government. Mr. Colon.

306. Public Policy Process (3) fall
Study of the American public policy process and analysis of its application. Ms. Katz-Olson.

308. Classical Political Heritage (3) spring
The contribution of significant political theorists from Plato to modern times. Mr. Yates.

311. Teaching Civil Liberties (3)
Consideration of fundamental civil liberties issues in constitutional perspective. Designed for improving the teaching of constitutional freedom in public and private schools. Freedom of speech, religious freedom, racial equality, censorship. Materials and methods for teaching the Constitution and the Bill of Rights. Designed primarily for secondary school teachers.

312. Workshop in Teaching Civil Liberties (3)
Research and library work, outside lectures, observation of court and administrative procedures pertaining to civil liberties. Must be taken concurrently with Govt. 311 when courses are offered together.

313. Teaching Government (3)
Consideration of contemporary issues which arise in the teaching of social studies in the public and private schools, including those governmental decisions which affect the educational environment. The course during any given year will focus its 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.

314. Workshop in Teaching Government (3)
Individual research projects on 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.

316. American Political Ideas (3)
A survey of the ideas underlying and associated with the political institutions and practices of the United States.

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. Ms. Katz-Olson.

318. Communist Political Systems (3)
Examination of communist political systems outside the U.S.S.R. and of the operations of non-ruling communist parties. Mr. Barry.

321. Methods for Political Research (3) spring
Introduction to research, research design (survey, experimental, aggregate), statistical and non-statistical analysis, and computer applications. Mr. Brownstein.

322. Politics of Developing Nations (3)
Theories of political development in non-Western areas, emphasizing the tasks of modernization and nation building. Field studies and methods will be examined. The contributions of related disciplines such as sociology and psychology will be explored.

324. Political Systems in Transition (3) spring
Studies of the responses of selected non-communist states to contemporary problems. May be repeated for credit with consent of department chairman. Mr. Yates.

325. Electoral Process (3)
Public opinion, voting behavior, campaigns and elections. Mr. Brownstein.

331. (U.S. 331). Urban Field Study (3) fall-spring
Integrated classroom and fieldwork approach to the study of local government; includes an internship in a local governmental or private agency. May be repeated for credit. Prerequisite: consent of chairman. Mr. Ruchelman.

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. Mr. Whitcomb.

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. Mr. Whitcomb.

353. Law and Politics (3)
An examination of the techniques of legal-political analysis and a study of the uses of the legal process in the political sphere. A large part of the course will involve the examination of law and politics in the United States, but pertinent materials and examples from other countries will also be drawn on. Mr. Barry.

354. Administrative Law (3)
Consideration of the authority, procedures, and methods utilized by executive agencies in the administration of public policy. Analysis of the general problem of adjusting the administrative process to traditional constitutional principles. Mr. Barry.

357. Technology Assessment (3)
Policy analysis of new and existing technologies in the United States; evaluation of societal consequences of technological decision-making and the identification of new alternatives in light of societal needs. Mr. Ruchelman.

358. Community and Regional Politics (3)
Analysis of the changing political dimension of community in the context of regionalism. Attention directed to "the metropolitan problem." Mr. Ruchelman.

359. The Legislative Process (3)
Organization and procedure of legislative and constituent assemblies. Legislative leadership. Role of administrative and judicial agencies in law-making. Pressure groups, parties, and policy determination. Direct legislation. Mr. Whitcomb.

360. Public Administration (3) spring
The nature of administration; problems of organization and management; public personnel policies; budgeting and budgetary systems; forms of administrative responsibility. Mr. Colon.

363. Contemporary Political Philosophy (3)
Analysis of selected concepts of contemporary political science; the alleged decline of political theory; positivistic and utopian political thought; the political person, political elites, and modes of political and governmental control. Mr. McCoy.

364. Contemporary Political Analysis (3)
Contributions of economic, biological, psychological and communication approaches to understanding political phenomena.

365. Political Values of Neo-Freudians and Existentialists (3)
The perspectives of Freud, Neo-Freudians such as Fromm and Marcuse, and Existentialists such as Sartre and Camus. Mr. Yates.

366. The Politics of Education (3) summer
An analysis of the political dimensions of the contemporary crisis in American education. Designed primarily for students in the School of Education.

368. Political Economy (3)
Significance to democratic theory of the concentration of economic power and its interface with the polity. Mr. McCoy.

371. Readings (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 department chairman.

372. Readings (3)
Continuation of Govt. 371. Prerequisite: consent of department chairman.

381, 382. Special Topics (3)
A seminar on a topic of special interest in a particular political institution, process, or policy. Prerequisite: consent of department chairman.

For Graduates

The department of government offers a graduate program leading to the Doctor of Arts (D.A.) and the Master of Arts (M.A.) degrees. The applicant for admission must demonstrate adequate undergraduate preparation and submit GRE results. Candidates for the master's degree in political science may qualify by completing thirty hours of approved course work and passing an examination covering the entire field or completing twenty-four hours in approved courses and submitting a satisfactory thesis. Candidates may also declare an Urban Studies option which includes a multi-disciplinary focus on the urban process.

Master of Arts. This degree is available for students interested in a variety of vocations. Principally, M.A. candidates prepare for careers in local, state or national government; public school teaching; governmental and private research programs; journalism; or further graduate study leading to a D.A. or Ph.D. and a career in community college or university teaching.

Urban Studies Option. Master's degree candidates in government can declare an option in the area of Urban Studies. This is a multi-disciplinary effort, drawing together the expertise of faculty members of other departments in addition to the government department. Core course requirements are as follows: Research in Urban Areas, Advanced Urban Seminar, Special Topics, Thesis Work. Recommended courses are Regional Science, Metropolitan Analysis, Community Power Structure, Urban Policy, Advanced Urban Sociology, Advanced Urban American History, Operations Analysis, Public Finance.

Doctor of Arts. The department of government offers a graduate program leading to the Doctor of Arts degree (D.A.). The program is designed for students holding the bachelor's or master's degree who wish to prepare for a career in college teaching of political science. In every respect, the evaluation standards are equal to those of a Ph.D. program. Guidelines developed by the Council of Graduate Schools and American Association of State Colleges and Universities have been followed in planning this program. The D.A. program will differ from the Ph.D. program in (a) the requirement of a broader distribution of graduate courses in government; (b) a minor area of study for those students who wish to have bi-disciplinary preparation for two-year college teaching; (c) course work and training in interpersonal awareness; (d) a general examination tailored to the D.A.; (e) a project of applied research rather than a dissertation, and (f) supervised internships.

The Doctor of Arts program consists of four parts: a core concentration in interpersonal awareness and teaching; a concentration in political science; a minor in a cognate field; and internships and project.

The entering student will follow any of three tracks depending on whether he or she is (1) beginning graduate work; (2) transferring up to 30 credit hours for an M.A. in political science; (3) transferring up to 30 credit hours for an M.A. in a cognate field.

The Core Curriculum (15 credit hours)

Interpersonal Awareness	(3)
Teaching Government	(3)
Research Methods	(3)
Teaching Electives	(6)

Political Science Concentration (33-45 credit hours)

Students entering the program with a B.A. or an M.A. in a cognate field will be required to take 33 credit hours in political science; those entering with an M.A. in political science will be required to take 15 credit hours at Lehigh in addition to the amount transferred.

The department requires general examinations in two out

of the following three fields: American Politics, Comparative Politics–International Relations, and Political Theory. However, one of these is to be designated by the student as his or her major field, the other as the minor. Moreover, the student may indicate an area of major emphasis, e.g., American–Public Administration.

The student is expected to register for 400-level (graduate seminars) courses where appropriate and it is expected that all students will take at least one seminar at Lehigh in each of the three fields identified above.

Cognate Minor (12 credit hours)

On the basis of interest and undergraduate education, students are encouraged to select their minor from a wide range of subject areas including both the natural and social sciences. Where possible this is related to the internship experience of the student. Associated with the department of government are the departments of social relations, and history, and the division of urban studies.

Students entering Lehigh with an M.A. in a cognate field may be excused from all course work in this area; however, they are still required to take the general examination in their cognate minor.

Internships and Project (12-30 credit hours)

The course credit allocated to the internships and project will vary from 12 credit hours for the student who transfers with an M.A. in a cognate field, to 30 credit hours for the student who enters the program with a B.A. Regardless of the credits allocated, the standards for the internships and project are identical.

Students participate in an evaluated, supervised, part-time teaching internship either at the junior or four-year college level for one semester.

Students also participate in a community organization internship on a part-time basis. The purpose of this internship is to sensitize them to a broad range of social and political problems in the larger society.

The students will complete a project of applied research of a pedagogical nature which is the functional equivalent of the dissertation in a Ph.D. program. Ideally, it should integrate his or her internship experiences.

Examination

Those students entering the D.A. program without the master's degree in political science will be required to take a continuing proficiency examination prior to their second year of study.

The general examination is taken prior to the commencement of the student's project. It consists of three parts as noted earlier: an examination in the cognate minor, and in the major and minor in the political science concentration. The examination is both written and oral.

401. Comparative State Politics (3)
The role of the states is analyzed within the American federal system. Emphasis is placed on the functions and policies of states and their relations with the national government. Mr. Colon.

403. The American Polity (3)
Integrative overview of the American polity emphasis on national institutions: presidency, Congress, judiciary, party systems and their interrelations.

413. Modern Political Philosophy (3)
A study of selected modern political philosophers and their continuing effect on polities and political philosophy. Mr. Yates.

414. Democratic Theory (3)
A critical evaluation of democratic theory in light of the contemporary challenges to the democratic process. Mr. McCoy.

421. Research Methods (3)
Research approaches, design techniques, statistical and non-statistical analysis, and computer applications. Mr. Brownstein.

424. Administrative Theory (3)
Administrative theory and practice in both the public and non-public sphere in the United States; model building and field research emphasizing the concepts of public and private administrative systems. Mr. Colon.

431. Public Administration (3)
The study of bureaucracy and the problems of public organization and management; executive leadership; personnel, budgeting and regulatory administration. Mr. Colon.

432. Public Policy Process (3)
Selected concerns of public policy such as poverty, welfare, environment, energy, and housing. May be repeated for credit. Ms. Katz-Olson.

434. Field Work in Political Science Application (3)
Internship in private or public civic agency. Primarily for Doctor of Arts students. May be repeated for credit.

441. Judicial Process (3)
An examination of judicial institutions and decision-making processes from various methodological approaches including political behavioralism and jurisprudence. Topics to be considered include judicial selection, interest group involvement, judicial policy-making, and proposals for judicial reform. Mr. Whitcomb.

443. Law and Social Policy (3)
The role of law in the development of social policy. Emphasis on judicial and administrative rather than legislative processes. Substantive areas vary from semester to semester; some of the topics are: judicial administration, administrative regulation, law and social change, and foreign legal systems. May be repeated for credit.

451. Comparative Politics (3)
The political systems of nations, with emphasis on Western and Western-type democracies. Approaches to the study of comparative politics.

452. Comparative Communist Political Systems (3)
The political systems of communist nations, with emphasis on the Soviet Union and Eastern Europe. Examination of methods and approaches used in the comparative study of communism. Mr. Barry.

460. Urban Policy (3)
An in-depth examination of the politics of urban policy areas such as housing, transportation, law enforcement, planning, welfare and poverty. Mr. Ruchelman.

461. Community Power Structure (3)
A focus on power relations and decision-making on the community level. Special attention given to theories of community power. Mr. Ruchelman.

471. Seminar in Teaching Government (3)
Theories and techniques of instruction, learning, evaluation, instructional design on innovation in the teaching of government. Prerequisite: Doctor of Arts candidacy or permission of the department chairman.

472. Workshop in Teaching Government (3)
Directed experience in teaching and instructional design of lower division government courses.

481. Special Topics (3)
Individual inquiry into some problems of government. Reading, field work, and other appropriate techniques of investigation. Conferences and reports. May be repeated for credit.

482. Special Topics (3)
Continuation of Govt. 481.

Division of Urban Studies

Associate Professors

Leonard I. Ruchelman, Ph.D., *Head*
Carlos Alvare, M. Arch., M.C.P.
James R. McIntosh, Ph.D.
Warren Pillsbury, Ph.D.

Assistant Professor

Roger Simon, Ph.D.

Lecturer

David Amidon, M.A.

Undergraduate Curriculum

This is an interdepartmental major intended for students who wish a broad interdisciplinary focus on urban processes as the means of comprehending multifaceted city problems. The Urban Studies major will help to prepare persons who wish to contribute to the solution of urban problems in a variety of ways: city management, urban planning, human relations, and social rehabilitation are examples of relevant career programs.

Students interested in the major should apply to the director of the division. An advisory council of chairmen from cooperating departments will assure interdisciplinary planning and coordination. Students must abide by the following three-level sequence of courses. A minimum of 42 credit hours is required.

Required preliminary courses (9 credit hours)

US 61	The Study of Urbanization (3)
US 62	Contemporary Urban Issues (3)

Research Methods: one of the following four courses

SR 211	Integrated Study of Social Relations (3) (SR 212 is recommended)
Govt 321	Methods for Political Research (3)
Hist 395	Quantitative Methods in Historical Studies (3)
Econ 45	Statistical Method (3)

Required core courses: 18 or 19 credits (choice of three out of five of the following sequences)

Econ 1	Economics (4)
Econ 312	Urban Economics (3)
FA 151 (US 151)	History of Urban Design (3)
FA 152 (US 152)	Physical Planning and Design (3)
Govt 77	Urban Politics (3)
Govt 358	Community & Regional Politics (3)
Hist 333	American Urban History to 1880 (3)
Hist 334	American Urban History, 1880 to Present (3)
SR 320	Urban Ethnology (3)
SR 368	The Urban Community (3)

Area Options: 15 credit hours required in one of the following areas:

Urban Management (prerequisite: economics and government sequences from above)

Acctg 108	Fundamentals of Accounting (3)
Eco 354	Public Finance: State & Local (3)
Eco 337	Transportation and Spatial Economics (3)
Govt 331 (US 331)	Urban Field Study (3)
Govt 360	Public Administration (3)
Govt 354	Administrative Law (3)
Mgt 321	Business and Organizational Behavior (3)

Urban Design (prerequisites: Fine Arts and History sequence from above)

Eco 337	Transportation and Spatial Economics (3)
FA 43	Environmental Design (3)
FA 143	Environmental Planning & Project (3)
FA 144	Intermediate Environmental Design (3)
FA 200	20th Century Architecture (3)
CE 13	Civil Engineering Concepts (3)

Urban Social and Political Processes (prerequisites: government, history, and social relations sequences from above)

Hist 8	Medicine and Society in America (3)
Hist 331	The Negro in America (3)

Hist 339	History of Public Health (3)
Govt 306	Public Policy Process (3)
SR 75	Minority Groups (3)
SR 391	Evaluation Research (3)
US 371, 372	Special Topics

Undergraduate Courses

32. The American Jewish Community (3) spring, alt. yrs. 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 sub-culture.

61. The Study of Urbanization (3)
Analyses of the city from early historical speculations to current behavioral analysis.

62. Contemporary Urban Issues (3)
Review of the literature on urban issues: poverty, law enforcement, race relations, planning and education.

325. American Ethnic Groups (3) fall
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-, Hispano-, Asian- and Native-Americans; basic historical approach in multidisciplinary social science framework; special materials on Bethlehem and Philadelphia.

371, 372. Special Topics (3 each)
A seminar on a topic of special interest in urban studies. Prerequisite: consent of the division head.

For Graduates

The urban studies graduate program is intended to meet the pressing need for urban generalists who possess interdisciplinary knowledge of urban processes. Depending upon interest and choice of courses, students will be prepared for careers in city management, urban planning and redevelopment, human relations, and social rehabilitation.

Master's degree candidates work within the disciplines of economics, government, history or social relations and are expected to achieve an urban concentration through the combined offerings of the social science departments. A student must fulfill the entrance requirements of the chosen department which formally admits him or her to the program. All students are required to take the urban seminar.

416. Urban Seminar (3)
A multi-dimensional overview of the urban condition. An examination of the interrelatedness of the social, political, economic, physical and historical forces which affect urban life and form.

Curricula

Beyond U.S. 416, Urban Seminar, student schedules are defined by the respective departments. Minimum requirements for each department are as follows:

Economics, advisor: Mr. Schwartz (30 credit hours)

Eco 312	Urban Economics (3)
Eco 354	Public Finance: State and Local (3)
Eco 440	Regional Science–Metropolitan Analysis (3)

Three additional courses in economics including:

Eco 432	Advanced Microeconomic Analysis (3)
Eco 436	Advanced Topics in Macroeconomics (3)

Two courses from the following:

SR 468	Advanced Urban Sociology (3)
SR 472	Special Topics (3)
Hist 442	Readings in United States History (3)
Hist 452	Research in United States History (3)
Govt 460	Urban Policy (3)
Govt 461	Community Power Structure (3)

A comprehensive examination (general economics, urban inquiry) is required.

Government, advisors: Messrs. Colon and Ruchelman (30 credit hours)

Govt 460	Urban Policy (3) or
Govt 461	Community Power Structure (3)
Govt 358	Community and Regional Politics (3)
Govt 321	Methods for Political Research (3) or
Govt 421	Research Methods (3)

Two courses from the following:

Eco 312	Urban Economics (3)
Eco 440	Regional Science–Metropolitan Analysis (3)
Hist 333	American Urban History to 1880 (3)
Hist 334	American Urban History, 1880 to Present (3)
SR 468	Advanced Urban Sociology (3)
SR 472	Special Topics (3)
	Thesis (6)

A comprehensive examination (theory, urban inquiry, option) is required.

History, advisor: Mr. Simon (30 credit hours)

Hist 401	Methods in Historical Research (3)
Hist 440s	Any course, including 442 when urban topic offered (9)
Hist 550s	Any course, including 452 when urban topic offered (6)

And one course from the following:

Hist 395	Quantitative Methods in Historical Studies (3)
SR 468	Advanced Urban Sociology (3)
Govt 460	Urban Policy (3) or
Eco 440	Regional Science–Metropolitan Analysis (3)
Govt 461	Community Power Structure (3)
	Thesis (6)

Satisfactory completion of this plan will enable a student to apply for candidacy for the Ph.D. in history.

Social Relations, advisor: Mr. McIntosh (30 credit hours)

Four courses, including:

SR 411	Advanced Research Methods (3)
SR 412	Practicum in Research Methods (3)

And two courses from the following:

Eco 312	Urban Economics (3)
Eco 440	Regional Science–Metropolitan Analysis (3)
Govt 460	Urban Policy (3)
Govt 461	Community Power Structure (3)
Hist 333	American Urban History to 1880 (3)
Hist 334	American Urban History, 1880 to Present (3)

Health Professions

Health Professions Advisory Committee

Ned D. Heindel, Ph.D., *Professor of Chemistry*
Chairman
G. Mark Ellis, Ph.D., *Associate Professor of History and Associate Dean*
Secretary
Steven S. Krawiec, Ph.D., *Assistant Professor of Biology*
Hayden N. Pritchard, Ph.D., *Associate Professor of Biology*
Jeffrey A. Sands, Ph.D., *Assistant Professor of Biophysics*
Keith J. Schray, Ph.D., *Assistant Professor of Chemistry*
Leonard A. Wenzel, Ph.D., *Chairman and Professor of Chemical Engineering*

Among the health professions programs offered at Lehigh are two introduced during 1975 which provide for accelerated education leading to both the baccalaureate and doctor of medicine degrees within a total of six years of study. A limited number of exceptionally well-qualified students are accepted for these special programs.

Lehigh-Hahnemann M.D. program

Lehigh University, in cooperation with Hahnemann Medical College and Hospital in Philadelphia, offers an accelerated six-year program leading to a combined baccalaureate degree and a doctor of medicine degree with an emphasis on family medicine. The program aims to increase the number of primary-health-care physicians in the Lehigh Valley and in eastern Pennsylvania by giving special preference to well-qualified students from these areas with a strong inclination toward family-practice medicine.

Two curricula are offered by Lehigh to the students who wish to be considered as candidates for the Hahnemann program: a biology and a chemistry major. Under both programs the student spends two academic years and two summers at Lehigh completing courses, which differ somewhat depending on the major chosen and total approximately 90 semester hours. The curricula followed will meet the biology, chemistry, physics, and mathematics prerequisites required for medical admission and will allow some flexibility in the selection of elective courses.

A joint Lehigh-Hahnemann selection committee will, in the student's second year of residence at Lehigh, select ten of the candidates based on academic achievement, maturity, and a sincere desire for family-practice medicine, and will recommend these students to Hahnemann Medical College. It should be emphasized that admission to Lehigh as a candidate in this Lehigh-Hahnemann program does not imply automatic admission to Hahnemann Medical College. Those of the group who choose not to continue or who are not admitted to Hahnemann at the end of the two-year curriculum still may continue in the traditional premedical program, may select other health profession fields, or may complete a standard biology or chemistry degree.

The chemistry major sequence in this accelerated medical education program requires an advanced placement exemption from general chemistry *or* the completion of this course in the summer before the freshman year. Because of this requirement for advanced standing it is possible for a student, should he or she not continue into Hahnemann at the end of two years of study, to complete a B.S. in chemistry in one more year. The student is then at liberty to apply for regular medical school admission or to pursue graduate work in chemistry.

Students selected to enter Hahnemann will spend their third academic year (first medical year) in the basic sciences core curriculum, including anatomy, biochemistry, physiology, microbiology, pharmacology, pathology, clinical science and behavioral problems.

The fourth year in the joint program is spent in clinical rotations through which students learn the elements of clinical medicine through intensive clerkships in each of the major divisions of medical practice: medicine, surgery, obstetrics and gynecology, psychiatry, and pediatrics.

The fifth year is an advanced clinical basic science exposure in which intensive correlative study applies the fundamental scientific principles to clinical medicine.

The sixth and final year will be conducted totally in the Lehigh Valley area utilizing local physicians and local medical facilities and will further acquaint the student with the challenges of family-practice medicine. The program will result in the awarding of a doctor of medicine degree from Hahnemann Medical College and a bachelor's degree (in either biology or chemistry) from Lehigh University.

The suggested sequence for the B.A. in biology is as follows:

Year 1: Lehigh University (two semesters):

Chem 21-22 (5)
Math 21 (4)
English (3)
Elective (Hum.) (3)
Elective (Soc. Sci.) (3)
Biol 21-22 (4)
Math 22 (4)
English (3)
Hist 8 (Soc. Sci.) (3)
Elective (Hum.) (3)

Summer 1: Lehigh University

Chem 51-53 (organic) (4)
Chem 52-54 (organic) (5)
Elective (Hum.) (3)

Year 2: Lehigh University (two semesters):

Phys 11-12 (5)
Math 23 (4)
Elective (Biology) (3)
Elective (Hum.) (3)
Elective (Soc. Sci.) (3)
Phys 13-14 (4)
Chem 194 (physical) (3)
Biology 28 (genetics) (3)
Elective (Hum.) (3)
Elective (Hum.) (3)
Elective (Soc. Sci.) (3)

Summer 2: Lehigh University

Elective (Soc. Sci.) (3)
Elective (free) (3)

The student has completed 90 credit hours of work at Lehigh University upon completion of the Summer 2 program.

The suggested sequences for the B.S. in chemistry are as follows:

Year 1: Lehigh University (two semesters):

Physics 11, 12 (5)
Math 21 (4)
English 1 (3)
Biology 21, 22 (4)
Chem 31 (3)
History 8 (3)
Math 22 (4)
English 2 (3)
Eco 1 (4).

Summer 1: Lehigh University

Chem 51, 53 (4)
GS requirement (3)
Chem 52 (3)
Math 23 (4)

Year 2: Lehigh University (two semesters):

Chem 187 (3)
Biol 28 (3)
Physics 21, 22 (5)
Chem 358(3)
GS requirement (3)
Chem 191, 188 (5)
Biol elective (3)
2 GS requirements (6)
Chem 54 (2)

Summer 2: (for those selected for medical school admission):

Chem 332, 234(4)
Chem 375 (3)

*Summer 2: (for others continuing at Lehigh toward a B.S. in chemistry *):*

Elective (3)
Chem 332, 234 (4)

Year 3: (for those continuing at Lehigh)

Chem 307 (3)
Chem 383 (4)
GS requirement (3)
Chem 381(3)
Chem electives (6)
Electives (15)

*During the internship, two additional three-credit chemistry courses will be taken at Lehigh.

Lehigh-Medical College of Pennsylvania program

In cooperation with the Medical College of Pennsylvania, Lehigh offers an accelerated six-year program which enables selected high school students to earn both the bachelor of arts (B.A.) degree in biology and the M.D. degree after a minimum of six years of study at the two institutions. The program as outlined below shows two academic years and two summers at Lehigh University. The student may prefer to spend three years at Lehigh before entering the Medical College of Pennsylvania, which is located in Philadelphia.

Application for admission to the program can be made jointly at both institutions through Lehigh's office of admission. Admission is based on SAT scores, scholastic achievement, maturity, and personal interviews at both institutions. Selection into the program ensures that the student will have the opportunity of entering medical school. The program is flexible, allowing students who do not choose to continue to transfer into other Lehigh courses of study.

The first two years of the six-year program (including summers) is spent at Lehigh, where participants take a basic biology course as well as those courses not available at MCP. This will include at least 90 credit hours of academic work.

They spend the next two years as medical students at MCP, after which they will have completed at least 30 credit hours of biology transfer credit and will receive the B.A. degree from Lehigh.

The final two years are spent in clinical medicine at MCP or at one of its affiliated hospitals, one of which is St. Luke's Hospital in Bethlehem. Upon completion of the final two years, participants will have completed all requirements for the M.D. from Medical College of Pennsylvania.

Year 1: Lehigh University

Chem 21-22 (5)
Math 21 (4)
English (3)
Elective (Hum.) (3)
Elective (Soc. Sci.) (3)
Bio 21-22 (4)
Math 22 (4)
English (3)
Elective (Hum.) (3)
Elective (Soc. Sci.) (3)

Summer 1: Lehigh University

Chem 51-53 (organic) (4)
Chem 52-54 (organic) (5)
Elective (Hum.) (3)

Year 2: Lehigh University

Phys 11-12 (5)
Math 23 (4)
Elective (Biology) (3)
Elective (Hum.) (3)
Elective (Soc. Sci.) (3)
Phys 13-14 (4)
Chem 194 (physical) (3)
Biol 28 (Genetics) (3)
Elective (Hum.) (3)
Elective (Hum.) (3)
Elective (Soc. Sci.) (3)

*Summer 2: Lehigh University**

Elective (Soc. Sci.) (3)
Elective (Free) (3)

*The student may opt to take the remaining courses during the third summer. It also should be noted that advanced placement will reduce the student's load. Upon completion of the course of study listed, the student has completed 90 credit hours of work, and all College of Arts and Science requirements.

History

Professors

Lawrence H. Leder, Ph.D., *Chairman*
Raymond G. Cowherd, Ph.D.
Joseph Albert Dowling, Ph.D.
John McVickar Haight, Jr., Ph.D.
Charles Leon Tipton, Ph.D.

Adjunct Professor

Winfred Kohls, Ph.D.

Associate Professors

John Hubert Ellis, Ph.D.
George Mark Ellis, Ph.D.
William Gerald Shade, Ph.D.

Adjunct Assistant Professor

Hans J. Finke, Ph.D.

Assistant Professors

Ian P. H. Duffy, D. Phil.
John Bingner Owens, Ph.D.
James Schofield Saeger, Ph.D.
Roger David Simon, Ph.D.

History is the study of human activities. As such, it encompasses not only events and public policy, but the whole sweep of cultural achievements—religion and philosophy, literature and art, economic and social life. Some of the most influential thinkers and public people of our time (Toynbee, Kennan, Churchill, Kennedy, among others) have studied contemporary problems by viewing the forces in the past which have shaped our world.

Students take courses in three culture areas, examining major developments in each in terms of cause and effect, the historians' main concern. These courses provide training in research, analysis of historical problems, and formulation of historical judgments, as well as in writing. History majors have the foundation for law school, government service, journalism, teaching, and graduate study.

Honors study in history is by invitation of the department in the student's junior year. The student must attain an average of 3.25 in history courses, and must demonstrate a special competence in history. Those interested in honors work are urged to consult the chairman of the department early in their junior year.

Honors students in history may plan special programs, including more in-depth study of two culture areas rather than three. They must enroll for three hours credit of unros-

tered history as part of their thirty-nine hours and must complete in that course an honors thesis.

Distribution Requirements

A history major must meet the following distribution requirements and the major must total 39 hours:

Hist 1, 2
Maximum of 12 hours in courses below 100
Minimum of 12 hours in courses numbered above 200, not including History 201 and 395
Hist 201 or 395
Maximum of 18 hours of courses from any one group, and minimum of three hours from each group listed below.

Group A Courses

Hist 5	The Machine in America to 1900 (3)
Hist 6	The Machine in Modern America (3)
Hist 8	Medicine and Society in America (3)
Hist 13	American Civilization (3)
Hist 14	American Civilization (3)
Hist 119	Colonial America (3)
Hist 120	Revolutionary America (3)
Hist 135	United States, 1789-1840 (3)
Hist 136	United States, 1840-1877 (3)
Hist 137	United States, 1877-1920 (3)
Hist 138	United States, 1920 to Present (3)
Hist 152	American Religions (3)
Hist 321	Social Class and Mobility in American History
Hist 322	American Economic History (3)
Hist 323	American Constitutional History (3)
Hist 324	American Constitutional History (3)
Hist 327	American Intellectual History (3)
Hist 328	American Intellectual History (3)
Hist 329	American Foreign Policy (3)
Hist 330	American Foreign Policy (3)
Hist 331	The Negro in America (3)
Hist 333	American Urban History to 1880 (3)
Hist 334	American Urban History, 1880 to the Present (3)
Hist 338	Psychohistory (3)
Hist 341	Development of Federal Science Policy (3)
Hist 342	The American Engineer (3)
Hist 374	Themes in American History (3)

Group B Courses

Hist 1	Course of Civilizations (3)
Hist 2	Course of Civilizations (3)
Hist 15	English History (3)
Hist 16	English History (3)
Hist 21	Ancient History (3)
Hist 22	Ancient History (3)
Hist 149	Barbarian West (3)
Hist 150	Medieval Civilization (3)
Hist 154	The Holocaust: History and Meaning (3)
Hist 157	The Renaissance and Reformation (3)
Hist 158	Age of the Baroque (3)
Hist 159	Modern Europe (3)
Hist 160	Modern Europe (3)
Hist 267	The Iberian Peninsula (3)
Hist 339	History of Public Health (3)
Hist 340	History of Medicine (3)
Hist 343	English History, 1471-1660 (3)
Hist 344	English History, 1660-1789 (3)
Hist 345	Liberal England (3)
Hist 346	Socialist England (3)
Hist 347	English Constitutional and Legal History to 1485 (3)
Hist 348	English Constitutional and Legal History Since 1485 (3)
Hist 351	Conservatism in the Modern Age (3)
Hist 355	European Intellectual History (3)
Hist 356	European Intellectual History (3)
Hist 361	A History of Russia to 1855 (3)
Hist 362	A History of Russia, 1855 to Present (3)
Hist 363	Modern Germany, 1618-1848 (3)
Hist 364	Modern Germany, 1848 to Present (3)

Group C Courses

Hist 4	Chinese Civilization (3)
Hist 49	History of Latin America (3)
Hist 50	History of Latin America (3)
Hist 65	Mediterranean Civilizations, 500-1200 (3)
Hist 66	Mediterranean Civilizations, 1200-1700 (3)
Hist 365	Colonial Latin America, 1492-1825 (3)
Hist 366	Modern Latin America, 1825 to Present (3)

History 51, 52, 300, 371, 372, or High Immediate Relevance courses will be placed in one of the above groups in accordance with their contents and emphases.

History majors are encouraged to enroll in courses in economics, English and American literature, government, international relations, philosophy, psychology, religion studies, and social relations. 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 in History

A student may establish a minor program in history which 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 *must* be prepared in consultation with the History Department chairman, must total at least fifteen hours and must conform 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

1. Course of Civilizations (3) P fall
Civilizations in the East, West, and Africa from earliest times to 1700. Mr. Haight.

2. Course of Civilizations (3) P spring
Civilizations in the East, West, and Africa from 1700 to the present. Mr. Haight.

4. Chinese Civilization (3) spring
Institutional, social and intellectual development of traditional China, and its transformation in the nineteenth and twentieth centuries. Mr. Owens.

5. The Machine in America to 1900 (3) P fall
Social history of American technology from the seventeenth century to 1900; the transplantation of a medieval technology and its displacement by a modern, industrial technology. Mr. Pursell.

6. The Machine in Modern America (3) P spring
The rapid intrusion of science into many areas of American life and the consequent changes in traditional technologies. Mr. Pursell.

8. Medicine and Society in America (3) P spring
Historical perspectives on values, ideas, and practices in American medicine. Mr. J. H. Ellis.

13. American Civilization (3) P fall
An integrated survey of political, social, cultural, and economic developments from the founding of Jamestown through Reconstruction.

14. American Civilization (3) P spring
Continuation of History 13; an integrated survey of political, social, cultural and economic developments from Reconstruction to the present.

15. English History (3) P fall
The history of England to 1688. The origins of representative government, the development of English social institutions, the unification of England, and the Renaissance and Reformation in England.

16. English History (3) P 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.

21. (Greek 21) Ancient History (3) P
For course description, see Classics.

22. (Latin 22) Ancient History (3) P
For course description, see Classics.

49. History of Latin America (3) P fall
Spanish and Portuguese colonization of America and the struggles for independence, preceded by a brief view of the ancient American civilizations and the Iberian backgrounds. Mr. Saeger.

50. History of Latin America (3) P spring
Continuation of History 49. The development of the Latin American nations in the nineteenth and twentieth centuries. Mr. Saeger.

51. Freshman Seminar (3) P
An intensive analysis of a particular period, problem or area of history, emphasizing readings, discussions, and reports. The topics and instructor will vary each semester. Open by invitation to students with Advanced Placement credit in history or equivalent background, or upon application to the chairman of the department.

52. Freshman Seminar (3) P
A continuation of History 51.

65. (Religion Studies 65). Mediterranean Civilizations, 500-1200 (3) P
Intellectual, political, and institutional aspects of Islamic, Christian, and Jewish civilizations in the Mediterranean basin. Emphasis upon the impact of Islam on the peoples of that region. Mr. Owens.

66. (Religion Studies 66). Mediterranean Civilizations, 1200-1700 (3) P
Rise and decline of the Ottoman, Venetian and Spanish empires, and their struggles for regional hegemony. Mr. Owens.

119. Colonial America (3) fall
Founding and growth of colonies in North America through c. 1750. Attention will be paid to motives behind European expansion as well as to developments in the colonies. Mr. Leder.

120. Revolutionary America (3) spring
American political, economic and cultural development from the mid-eighteenth century through the adoption of the Federal Constitution. Mr. Leder.

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. Mr. 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 post-war Reconstruction. Mr. 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 post-war developments. Mr. Simon.

138. United States, 1920 to Present (3)
American institutions in the modern era, emphasizing critical changes of the 1920s, the Crash of 1929, the New Deal, World War II, and later political, social and economic events. Mr. Dowling.

149. The Barbarian West (3) fall
Merger of Greco-Roman, Germanic, and Christian institutions and culture in Western Europe to mid-eleventh century. Evolution of the church, feudalism, and manorialism, and the foundations of the Carolingian and Holy Roman empires. Mr. Tipton.

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. Mr. Tipton.

152. (Religion Studies 152). American Religions (3)
For course description, see Religion Studies.

154. (Religion Studies 154). The Holocaust: History and Meaning (3)
For course description, see Religion Studies.

157. The Renaissance and Reformation (3) fall
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. Mr. Owens.

158. Age of the Baroque (3) spring
Developments in seventeenth- and eighteenth-century Europe which made it a major pre-industrial civilization. Mr. Owens.

159. Modern Europe (3) fall
Revolutions and reactions in Western Europe from 1789 to 1870. The rise and spread of liberalism and the origins of socialism. Mr. Haight.

160. Modern Europe (3) spring
Contemporary Europe; the origins and consequences of two World Wars; the rise of revolutionary governments in Italy, Germany, and Russia. Mr. Haight.

For Advanced Undergraduates and Graduates

201. Historical Perspectives (3) spring
Methodologies and interpretations of Western historians from ancient times to the present. Mr. Tipton.

267. The Iberian Peninsula (3)
Rise and decline of Spain and Portugal as European and colonial great powers in the early modern period; their development after the Industrial Revolution; emphasis on the Spanish Civil War (1936-39).

300. Apprentice Teaching (3)

321. (S.R. 321) Social Class and Mobility in American History (3)
The distribution of wealth, concepts of class and social democracy, lifestyles and values of different social and economic groups, and opportunities for mobility; colonial times to the present. Mr. Simon.

322. American Economic History (3)
Economic development since the colonial period, emphasizing the rapid industrialization from 1820 to 1890 and the social impact of economic change. Mr. Simon.

323. American Constitutional History (3)
Legal institutions from the founding of Jamestown through the Civil War. Emphasis on federalism, judicial review, and the interplay between judicial and legislative institutions.

324. American Constitutional History (3)
The response of legal institutions to the crisis of Reconstruction and the challenge of industrialization. Emphasis on "due process," the changing legal status of minorities, and the national government's rise to dominance.

327. American Intellectual History (3) fall
Development of political, social, and religious ideas in America from the colonial period to the Civil War. Mr. Dowling.

328. American Intellectual History (3) spring
Economic, political, and religious thought in industrial America, 1860 to the present. Mr. Dowling.

329. American Foreign Policy (3)
The French alliance; independence and boundaries; commercial restrictions; French Revolution and neutrality; purchase of Louisiana; War of 1812; acquisition of Florida; Monroe Doctrine; relations with France and Great Britain; Oregon and Texas; the Mexican War; Civil War diplomacy.

330. American Foreign Policy (3)
Maximilian in Mexico; Seward and expansion; Alaska boundary; War with Spain; the new Caribbean policies; the World War of 1914-1918 and its aftermath; diplomatic events preceding Pearl Harbor; outbreak and prosecution of the war; plans for peace; the "Cold War"; diplomacy since 1945.

331. The Negro in America (3) fall
Negro subculture in America from the colonial period to the present, emphasizing the struggle for emancipation and equal rights. Topics include: racialism, slavery, Reconstruction, urbanization, protest movements, and the "Second Reconstruction." Mr. J. H. Ellis.

333. American Urban History to 1880 (3) fall
Planning and design of colonial and frontier cities. Impact of transportation innovations and industrialization, emergence of a national system of cities. Internal problems of early industrial cities: housing, transportation, public health, crime, social mobility. Mr. Simon.

334. American Urban History, 1880 to Present (3) spring
Physical expansion of the industrial city and its relationship to current urban problems. Suburbanization, development of the central business district, reforms in housing and public health, rise of ghettoes, emergence of the city planning profession and the idea of "new towns," impact of the New Deal and "urban renewal." Mr. Simon.

338. Psychohistory (3) spring
Uses of psychology in history and biography; exploration of problems of methodology, verification of evidence, conceptual frameworks and theories of personality; potentialities and limitations of psychological investigation as an historical technique. Mr. Dowling.

339. History of Public Health (3) fall
Ideas and major institutional developments concerning health and disease from ancient times to the present. Mr. J. H. Ellis.

340. History of Medicine (3) spring
Ideas and major developments in the theory and practice of medicine from ancient times to the present. Mr. J. H. Ellis.

341. Development of Federal Science Policy (3) fall
Institutional origins and evolution of federal science policy from the early republic to the present, emphasizing the period since 1939. Mr. Pursell.

342. The American Engineer (3) spring
Social history of the development of an engineering profession from the early republic to the present. Mr. Pursell.

343. English History, 1471-1660 (3)
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. Mr. G. M. Ellis.

344. English History, 1660-1789 (3)
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. Mr. G. M. Ellis.

345. Liberal England (3) fall
Political and social history, 1790-1870; transition from aristocracy to democracy; the influence of the utilitarians; radical reforms and reactions; the impact of the industrial and agricultural revolutions.

346. Socialist England (3) spring
Political and social history, 1870-1970; the expansion of democracy; the growth of the Labor Party; the impact of the second industrial revolution; the making of the welfare state; the consequence of two World Wars.

347. English Constitutional and Legal History to 1485 (3) fall
Origins and developments of government, administration, and law from Anglo-Saxon times to 1485, emphasizing common law institutions, practices, and procedures.

348. English Constitutional and Legal History Since 1485 (3) spring
Emphasis on development and problems of sovereignty, constitutional monarchy, the cabinet system, and legal and administrative changes in the modern era.

351. Conservatism in the Modern Age (3)
Conservative political, economic, and social thought from the eighteenth century to the present. Mr. Tipton.

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.

356. European Intellectual History (3)
A continuation of History 355, with special attention given to the impact of the Industrial Revolution upon the development of nineteenth- and twentieth-century ideologies.

361. A History of Russia to 1855 (3) fall
Major cultural, social, and political traditions of the Russian people. Mr. Kohls.

362. A History of Russia, 1855 to Present (3) spring
The Great Reforms, collapse of Tsarist absolutism, revolutions of 1917, and formation and consolidation of the Soviet dictatorship. Mr. Kohls.

363. Modern Germany, 1618-1848 (3) fall
Political, socio-economic, and cultural developments from the age of triumphant absolutism to the failure of liberalism. Mr. Finke.

364. Modern Germany, 1848 to Present (3) spring
Political history from the Second Empire to the federal and socialist republics. Twentieth-century intellectual and social problems. Mr. Finke.

365. Colonial Latin America, 1492-1825 (3) fall
Individual investigation and reports on selected topics. The Spanish concept of empire, church-state relations, origins of the Wars of Independence. Mr. Saeger.

366. Modern Latin America, 1825 to Present (3) spring
Individual investigation and reports on selected topics. Nationalism, conservatism, and liberalism in the nineteenth century; the rightist revolutions, socialism, and communism in the twentieth century. Mr. Saeger.

371. Special Topics in History (3)
Intensive study in an area of history not adequately covered in currently listed offerings. The course may be administered as a reading program or otherwise as may seem best to meet the needs of students of unusual ability and adequate preparation. Prerequisite: consent of department chairman.

372. Special Topics in History (3)
Continuation of History 371. Prerequisite: consent of department chairman.

374. Themes in American History (3) fall
An intensive study of a selected topic in American history primarily for American Studies majors. The topic may vary from time to time as the needs of the American Studies program dictate. The seminar will allow study of an aspect of

American history in greater depth than is generally the case. Prerequisite: permission of director of American Studies. Mr. Dowling.

395. Quantitative Methods in Historical Studies (3) spring
Historical uses and methods of quantitative analysis, including the application of descriptive statistics, statistical inference, and computer technology to a variety of problems drawn from European, American, and Latin American history. Mr. Shade.

For Graduates

Linderman Library is especially rich in materials for advanced study and research in history, and the department of history offers programs leading to master of arts and doctor of philosophy degrees. Graduate programs provide intensive and specialized study, and limited enrollment maintains 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 in the Graduate School section of the catalog, the following special requirements apply to graduate study in history.

Master of Arts. There are two master's programs. Under plan I, a candidate may earn the degree by successfully completing twenty-four hours of approved course work and submitting a satisfactory thesis. Those continuing toward a doctorate must elect Plan I. Candidates declaring Plan II do not write a thesis, but take thirty hours of course work in and pass examinations in two fields chosen from American, British, European and Latin American history. Master's candidates must maintain a 3.0 average in all graduate work.

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 their second semester at Lehigh doctoral students select four history fields and one outside field and prepare themselves for written and oral examinations in those fields. Course work is required in a fifth history field, but it will not be covered in the comprehensive examinations. An original dissertation is required and may be written only in a primary field.

Primary Fields. Primary fields are Great Britain, Colonial America, Nineteenth-Century America, and Twentieth-Century America.

Other fields. Other fields of specialization are Medieval–Renaissance, Modern Europe to 1789, Modern Europe since 1789, and Latin America.

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 will normally be chosen from among French, Spanish, Italian, German and Russian.

All graduate majors must take History 401.

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. Mr. Tipton.

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.

441. Readings in Colonial 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 Colonial American history. May be repeated for credit with permission of department chairman.

442. Readings in United States History (3)
Study in small groups under the guidance of a faculty member of the literature of a particular period, problem, or area of United States history. May be repeated for credit with permission of 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 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 department chairman.

445. Readings in Medieval and Renaissance European History (3)
Study in small groups under the guidance of a faculty member of the literature of a particular period, problem, or area of Medieval and Renaissance European history. May be repeated for credit with permission of department chairman.

446. Readings in Early Modern European History (3)
Study in small groups under the guidance of a faculty member of the literature of a particular period, problem or area of Early Modern European history. May be repeated for credit with permission of department chairman.

447. Readings in Modern European History (3)
Study in small groups under the guidance of a faculty member of the literature of a particular period, problem, or area of Modern European history. May be repeated for credit with permission of department chairman.

451. Research in Colonial American History (3)
An intensive research seminar on a phase of American colo-

nial history. Prerequisite: appropriate undergraduate course work (or its equivalent), or an appropriate Readings Seminar. May be repeated for credit with permission of department chairman.

452. Research in United States History (3)
An intensive research seminar on a phase of United States history. Prerequisite: appropriate undergraduate course work (or its equivalent), or an appropriate Readings Seminar. May be repeated for credit with permission of department chairman.

453. Research in English History (3)
An intensive research seminar on a phase of English history. Prerequisite: appropriate course work on the 300 level (or its equivalent), or an appropriate Readings Seminar. May be repeated for credit with permission of department chairman.

454. Research in Latin American History (3)
An intensive research seminar on a phase of Latin American history. Prerequisite: appropriate course work on the 300 level (or its equivalent), or an appropriate Readings Seminar. May be repeated for credit with permission of department chairman.

455. Research in Medieval and Renaissance European History (3)
An intensive research seminar on a phase of Medieval and Renaissance European history. Prerequisite: appropriate undergraduate course work (or its equivalent), or an appropriate Readings Seminar. May be repeated for credit with permission of department chairman.

456. Research in Early Modern European History (3)
An intensive research seminar on a phase of Early Modern European history. Prerequisite: appropriate undergraduate course work (or its equivalent), or an appropriate Readings Seminar. May be repeated for credit with permission of department chairman.

457. Research in Modern European History (3)
An intensive research seminar on a phase of Modern European history. Prerequisite: appropriate undergraduate course work (or its equivalent), or an appropriate Readings Seminar. May be repeated for credit with permission of department chairman.

Industrial Engineering

Professors

George Eugene Kane, M.S., *Chairman*
Arthur Freeman Gould, M.S.
Sutton Monro, B.S.
Wallace James Richardson, M.S.
Gary E. Whitehouse, Ph.D.

Associate Professors

John William Adams, Ph.D.
Mikell Porter Groover, Ph.D.

Assistant Professors

Lucius J. Riccio, Ph.D.
Ben L. Wechsler, Ph.D.
Emory W. Zimmers, Jr., Ph.D.

Instructors

John W. Nazemetz, B.S.
Louis S. Plebani, M.S.

The curriculum is designed with the principal aim of industrial engineering in view, which is the design, improvement, and installation of integrated systems of people, materials, and equipment for operations by the application of the principles of the mathematical, physical, and behavioral sciences.

Throughout the program there is an integrated series or sequence in the major field which includes not only basic and fundamental courses but specialized courses as well, in the fields of production planning and control, quality control, production engineering, information systems, operations research, and industrial personnel management. These specialized courses reflect the impact of recent developments in operations research, information processing, and automation, and considerable course work involves use of the high-speed digital computer.

There is a growing tendency on the part of industries to select young people from their engineering departments for managerial positions. Because of this the industrial engineering courses are oriented to the principles of scientific management to enable the industrial engineering graduate to accept and succeed in these opportunities.

It is the aim of the industrial engineering program to develop the potential manager for either the manufacturing or service industry as well as the government agency, a graduate well grounded in the fundamentals of science, trained in the principles of engineering analysis and design, and thus adequately prepared to practice the profession of industrial engineering.

Freshman Year (See page 52)

Sophomore Year, First Semester (15 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
IE 5	Industrial Engineering Models (3)
Phys 21, 22	Introductory Physics II & Lab (5)
	Engineering Science Elective (3)

Sophomore Year, Second Semester (16 credit hours)

IE 110	Engineering Probability (3)
IE 18	Data Processing Fundamentals (3)
	Engineering Science Electives (6)
Eco 1	Economics (4)

Junior Year, First Semester (16-19 credit hours)

IE 101	Fundamentals of Manufacturing Engineering (4)
IE 205	Engineering Statistics (3)
Math 205	Linear Methods (3)
	Engineering Science Elective (3)
	GS Elective (3)
	Elective (0-3)*

Junior Year, Second Semester (16-19 credit hours)

IE 102	Work Systems (3)
IE 206	Operations Research Techniques (4)
	Engineering Science Electives (6)
	GS Elective (3)
	Elective (0-3)*

Summer

IE 100	Industrial Employment

Senior Year, First Semester (15-18 credit hours)

Acctg 108	Fundamentals of Accounting (3)
IE	Electives (6)
	Engineering Science Elective (3)
	GS Elective (3)
	Elective (0-3)*

Senior Year, Second Semester (15-18 credit hours)

IE 154	Project (3)
IE	Electives (9)
	GS Elective (3)
	Elective (0-3)*

For engineering science electives see approved list in Industrial Engineering office.

*Please refer to description of normal program, page 52.

Undergraduate Courses

5. Industrial Engineering Models (3)
Deterministic models in the planning activities associated with industrial engineering, including engineering economy, flow chart construction and analysis, and fundamentals of production control. Prerequisite: Engr. 1 or equivalent experience in programming.

18. Data Processing Fundamentals (3) spring
Study of data representation and recording media. The functions of input/output devices, storage devices and the central processing unit in the conversion of data to information. Fundamentals of system analysis and design. Programming projects using FORTRAN IV and COBOL. Prerequisite: Engr. 1 or equivalent.

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.

101. Fundamentals of Manufacturing Engineering (4) fall
Study of metal processing theory with emphasis on machining, numerical control, special processing techniques, workholder design, laboratory experiments.

102. Work Systems (3) spring
Techniques in methods improvement and work measurement. The applications of these techniques to the analysis, design and control of man-machine work systems. Time study, predetermined time systems, work sampling and standard data. Plant layout project. Prerequisites: I.E. 101, I.E. 205.

105. Thesis (3-6)
Candidates for the bachelor's degree in industrial engineering may, with the approval of the department staff, undertake a thesis as a portion of the work of the senior year. Prerequisite: senior standing.

110. Engineering Probability (3) spring
Introduction to the use of probability to solve engineering problems. Sampling distributions for estimation and elementary stochastic processes for modelling. Prerequisite: Math. 23 previously or concurrently.

154. Senior Project (3) spring
Special study of a particular problem involving laboratory work and/or work in local industrial plants. Prerequisite: senior standing in industrial engineering.

166. Production Management (3) fall-spring
A course for non-engineering majors. Study of production functions including production planning, scheduling, inventory control, quality control, work measurement, methods analysis, and facilities planning. Prerequisites: Math. 42, Eco. 1.

168. Production Analysis (3) fall-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. 22 or 42; Eco. 1.

For Advanced Undergraduates and Graduates

205. Engineering Statistics (3) fall
Applications of point and confidence interval estimation and hypothesis testing to the fitting of frequency and regression models, to acceptance and control sampling and to elementary design of experiments. Prerequisite: I.E. 110 or Math. 231, or equivalent.

206. Operation Research Techniques (4) spring
The development and use of the techniques of operations research. Topics include linear programming, queueing theory, dynamic programming, probabilistic inventory models, and simulation. Prerequisites: I.E. 110 or Math. 231, Math. 205.

212. Elementary Design of Experiments (3)
An introduction to the structure of experiments, the analysis of experimental data, and their interrelation. Measurement error, randomization, pairs and blocks; regression and analysis of variance. Prerequisite: graduate standing or consent of department chairman.

300. Apprentice Teaching in I.E. (1-3)

307. Information Systems Engineering (3) fall
Information systems design methods. Graphical and matrix techniques. Boolean logic. Information network models and feedback concepts in dynamic information systems. Prerequisites: Math. 205, 231 or I.E. 110.

309. Data Processing Systems (3) fall
Analysis and planning of data systems to store and process data; management of electronic data processing; feasibility studies and economic analysis; effects on organizational relationships. Prerequisite: I.E. 18 or equivalent.

310. File Structure and Processing (3) spring
Organizing data files for effective processing by computer. Coverage in depth of coding and filing; list processing; search strategy; scoring techniques; randomizing and chaining; data management procedures; coordinate indices. Demonstrations, student projects on computer. Prerequisite: I.E. 309 or consent of department chairman.

311. Decision Processes (3) spring
Application of the techniques of operations research for making decisions, including decisions under certainty, decisions under risk, and decisions under uncertainty. Emphasis will be placed on the application of simulation in decision-making. Prerequisite: I.E. 206 or consent of department chairman.

313. Quantitative Analysis of Criminal Justice (3) fall
Quantitative approaches to administrative problems of the criminal justice system, and issues associated with crime control. Application of simulation, queueing theory, and dynamic programming as well as classical optimization techniques to problems in police and court administration and crime control strategy evaluation. Prerequisites: I.E. 110 or Math 231, I.E. 18 or consent of department chairman.

321. Experimental Industrial Engineering (1-3)
Experimental projects in selected fields of industrial engineering, approved by the instructor. A written report is required.

322. Experimental Industrial Engineering (1-3)
Continuation of I.E. 321.

325. Production Control (3) fall
A study of the decision rules, and mathematical and economic models of production forecasting, scheduling, order control, and inventory control. Case problems and laboratory. Prerequisite: I.E. 206 or consent of department chairman.

334. Organizational Planning and Control (3) spring
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. Prerequisites: I.E. 102 or 166 or 168.

335. Sampling and Quality Control (3) fall
Random, stratified and optimal sampling plans, using fixed and sequentially determined sample sizes. Application to quality assurance and other analyses of operations. Stochastic methods for continuous inspection and Bayesian procedures for acceptance inspection. Prerequisite: I.E. 205 or consent of department chairman.

336. Analysis of Experimental Data (3) spring
Design of simultaneous experiments including randomization, blocking, analysis of variance with equal cell frequencies and general regression. Prerequisite: I.E. 205 or consent of department chairman.

340. Production Engineering (3)
Introduction to mechanization and automation of product manufacturing. Partial mechanization, engineering materials utilization, product design analysis, special processing methods, economic analysis of processing design alternatives. Term project. Prerequisite: I.E. 101.

342. Computer-Aided Manufacturing (3)
Analysis and design of manufacturing systems using digital computers. Principal topics: computer-aided design techniques, group technology, applications of mini-computers to manufacturing systems. Introduction to adaptive control, numerical control, and optimization strategies for discrete parts manufacturing. Term project. Prerequisites: I.E. 18, I.E. 101 or consent of department chairman.

344. Metal Cutting Theory (3) spring
Intensive study of metal cutting emphasizing temperature and energy relationships and their effect on tool life, power requirements and surface finish. Economic balancing of metal cutting variables from application of theory. Lectures and laboratory experiments including designing and conducting an original experiment. Prerequisite: I.E. 101.

For Graduates

Programs leading to the M.S. and Ph.D. degrees are offered by the department of industrial engineering in the following fields: manufacturing engineering, information systems, and operations research.

Master of Science in Industrial Engineering

The minimum program for the M.S. degree consists of twenty-four hours of approved course work and completion of a satisfactory thesis.

An M.S. program is selected to meet the interests and needs of the student, and courses in other departments for which the student has the prerequisites may be integrated into the major field. Subject to proper approval, nine hours of 400-level courses from outside the department may be included among the courses required in the major field. As part of a purposeful major program, collateral courses may be taken in other branches of engineering, mathematics, economics, psychology, and information science.

Doctor of Philosophy in Industrial Engineering

The Ph.D. program is organized to meet the individual goals and interests of industrial engineering students who plan to engage in teaching, consulting, or research activities in industrial, governmental, or educational environments. The objective of the program is to educate these students to perform their respective activities at a high level of proficiency. To this end, each doctoral student is required to: (1) demonstrate competency in several broad fields of industrial engineering related to a personal area of interest; (2) prepare, through formal course work and independent study, for examination in the student's particular area of specialization by members of the graduate faculty; and (3) present a dissertation related to the student's field of specialization which embodies the results of original research, shows evidence of high scholarship, and constitutes a contribution to knowledge.

Further information about the Ph.D. program is contained in the Graduate School section of this catalog and in a brochure prepared by the department.

Areas of Graduate Study. The areas of graduate study and research which are emphasized in the department of industrial engineering are:

Operations Research. Emphasis is placed on both the development and applications of Operations Research techniques. The program is strongly analytical in approach and content. Emphasis is placed on understanding practical problems so that suitable mathematical models can be selected or developed. Such models may be drawn from such areas as inventory theory, queueing theory, simulation, decision theory, dynamic programming, and mathematical programming theory. The operations research student is motivated by a program which emphasizes the mathematical, probabilistic, statistical, and computer sciences.

Information Systems. The field of information systems embodies management information for decision-making and planning, operational systems to control man-machine activity, and methods for system analysis and design. The role of the human is stressed in data gathering, information processing and interaction with system output. Study and research work relate to performance of computer-based systems, including evaluation criteria and cost effectiveness. Project management, simulation, data management and economic analysis principles and techniques are employed as basic tools in research activities.

Manufacturing Engineering. Graduate study in manufacturing engineering involves course work and research opportunities in specific areas related to manufacturing. The department is currently interested in such areas as metal processing theory, automation and numerical control, manufacturing systems and management, and work systems. Additional related courses are offered in other departments in the College of Engineering and Physical Sciences. The Manufacturing Processes Laboratory is available for the study of metal cutting processes and the lab is coupled with course offerings in the same area.

Facilities. The offices and laboratories of the department are located in the James Ward Packard Laboratory. Available for graduate study and research within the department is a modern metal processing research laboratory. The University's Computing Center, located also in Packard Laboratory, is equipped with a CDC 6400 system.

The department offers courses during the late afternoon for the convenience of students who are employed in local industry and are taking graduate work on a part-time basis. There is no evening program, however.

405. Special Topics in Industrial Engineering (3)
An intensive study of some field of industrial engineering.

408. (Acctg. 408) Management Information Systems (3)
Information as a resource for management planning and control. Integrated and total systems concepts for organizational data files and information processing. Development and implementation of computer-based information systems. Prerequisite: Acctg. 311 or I.E. 309 or I.S. 422 or consent of department chairman.

410. Design of Experiments (3)
Fixed, mixed, and random models, fractional factorials, unequal cell frequencies. Sequential design for estimation and optimization. Prerequisite: a course in statistical inference.

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 principles of optimality; one-dimensional processes, multi-dimensional processes, lagrange multiplier technique; markovian decision processes; applications.

417. (Mgt. 417) Advanced Mathematical Programming (3)
Theory and applications of the extensions of linear programming. Kuhn-Tucker conditions, gradient methods of optimization, simplex based methods of non-linear programming, integer programming, branch and bound, zero-one discrete programming and stochastic programming. Prerequisite: a course in linear programming.

418. Simulation (3) fall
Random number generation and testing; design of simulation experiments for the reduction of variance of estimators; simulation languages; application of simulation to industrial problems. Prerequisite: knowledge of FORTRAN and a course in probability theory.

425. Production Systems (3)
Mathematical models of production systems; adaptive control applied to production systems; computer process control; interaction of physical system and information system, dynamic simulation.

426. Inventory Theory (3)
Optimal policies in deterministic inventory processes; optimal policies in stochastic inventory processes; operating characteristics of inventory policies. Prerequisite: a course in probability theory.

427. Queueing Theory (3)
Single server queueing processes, Poisson input and exponential service times, Poisson input and general service times, derivation of busy period distributions; many server queueing processes; applications. Prerequisite: a course in probability theory.

428. Advanced Work Systems (3)
A critical evaluation of methods improvement and work measurement techniques. Emphasis on the design of complex work systems, and reporting systems to control work. Work sampling, construction of standard data, mathematical models of work systems. Student projects.

429. Stochastic Processes for Engineers (3)
Markov chains. Applications include inventories, queues, random walk. Also discussed are discrete models of Brownian motion and diffusion processes. Prerequisites: a course in probability theory and a course in linear algebra.

430. (Mgt. 430) Management Science Project (3) spring
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. Information Systems Seminar (3)
Extensive investigation of selected topics in theory, analysis and design of information systems.

438. Real Time Information (3)
Planning and management of real time, on-line information systems; effect of data banks, multi-processing, time-sharing, and supervisory routines; data gathering and display techniques for interactive systems; data communications. Prerequisite: I.E. 310 or consent of chairman of department.

440. Application of Automation (3)
Study of concepts and principles of design in fully automatic production lines; influence of economic factors; partial automation; integration into existing production systems. Case histories with emphasis on problems involved in application of principles. Plant visits and guest lecturers.

441. Network Modeling Techniques (3)
A critical study of various network modeling techniques. Topics include: PERT, CPM, network flows, decision trees, flowgraph analysis and GERT. Emphasis will be placed on the modeling and analysis of systems using these techniques.

444. Design of Cutting Tools (3)
A study of design parameters including tool materials, tool geometry and cutting conditions for material removal operations. Emphasis will be placed on the influence of tool selection variables, on economy of operation and conformance to product requirements.

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.

461. Readings (1-3)
Intensive study of some area of industrial engineering which is not covered in general courses.

490. Research Methods Seminar (3)
Research methods in industrial engineering; discussion and critical analysis of current industrial engineering research; practice in preparation of research proposals.

International Relations

Professors

Oles M. Smolansky, Ph.D., *Chairman*
Henderson Bampfield Braddick, Ph.D.
Carey Bonthron Joynt, Ph.D., *Rathbone Professor*

Associate Professor

Zdenek J. Slouka, Ph.D.

Assistant Professor

Michael R. Hodges, Ph.D.

Instructor

Raymond F. Wylie, M.A.

The field of international relations poses an unprecedented challenge to student and teacher alike and provides a stimulating focus of interest for undergraduate education. It demands full recognition and understanding of the vast forces which are shaping the world—wars, nationalism, political ideologies, and modern technology. The leadership and responsibilities of the United States in the world arena have created a need for broadly educated men and women who possess a clear appreciation of the factors which influence the policies of nations.

Students will approach the study of state behavior through courses in the theory and techniques of diplomacy, the history of modern international relations, and special seminars in international law, international organization, and world politics. The ultimate objective is to shape and develop well-informed and independent observers and participants in the field of international affairs. The flexibility of the program permits added study in history, government, economics and other social sciences.

A special course is available in World Order Studies, a program which takes special account of the problems of world peace, transnational relations and the impact of science and technology on international relations. Students taking this option should select twelve semester hours, in addition to their required major courses, from the following list: I.R. 41, 47, I.R. 101, I.R. 301-305.

The broad knowledge and understanding acquired can be utilized in careers in teaching, the Foreign Service of the United States and other government agencies, international business, and the legal profession.

Required Preliminary Course

IR 1, 2 World Politics (6)

Required Major Courses

IR 341, 342 International Relations (6)
IR 353 International Institutions (3)
IR 354 The Atlantic Community (3)
IR 361, 362 International Law (6)
IR 371, 372 Readings in International Relations (6)

and twelve semester hours to be selected, with the approval of the chairman of the department, from international relations, history and government. A senior essay is required.

Undergraduate Courses

1. World Politics (3) P
An introductory analysis of the major concepts, principles and problems involved in an understanding of world politics. An interdisciplinary approach is used, stressing the impacts of behavioral, political, economic, demographical, military, legal and institutional factors on international relations. Considerable emphasis is placed upon current international developments, essentially as case studies. Mr. Hodges.

2. World Politics (3) P
An introduction to the foreign policies of the Great Powers—the United States, the Soviet Union, Britain, France, Germany, Japan, China and India—and of regional groupings in Asia, the Pacific, the Middle East, Black Africa and Latin America. Considerable emphasis is placed upon current international developments, essentially as case studies. Mr. Hodges.

11. European International Relations, 1815-1919 (3) P
Politics of the Great Powers; clashes of interests and international crises; development of alliances and other associations of states; wars and peace settlements; unification of Germany and Italy; European imperialism; World War I and the peace treaties. Mr. Braddick.

12. European International Relations Since 1919 (3) P
The political and strategic structure of Europe in the 1920s; the rise of Germany under Hitler; the politics of international crises, 1935-39; World War II and the new distribution of power in Europe; development of the Cold War; European functional integration; contemporary European international problems; European relations with the United States. Mr. Braddick.

21. Asian International Relations to 1945 (3) P
Asian international relations from earliest times to 1945, with emphasis on the twentiety century: geography of Asia; traditional Asian states and international systems; impact of western expansionism; response of Asian states; rise of communism in China; and development of American-East Asian relations. Mr. Wylie.

22. Asian International Relations Since 1945 (3) P
Asian international relations from 1945 to the present: geographic/resource base; major events since World War II; foreign policies of Asian states; role of USA and USSR in Asia;

transnational relations in Asian region; and current problems in Asian international politics. Mr. Wylie.

31. The Middle East in World Affairs I (3) P
Analysis of the political, economic, and social forces which have led to the rise of the modern states in the Middle East. Emphasis upon the role of the area in international politics from the invasion of Egypt by Napoleon to the end of World War II—the beginning of the rapid decline of western influence in the Middle East. Mr. Smolansky.

32. The Middle East in World Affairs II (3) P
The rise of Turkish, Iranian, and Arab nationalism; the creation of Israel: the decline of British and French power, and the corresponding growth of U.S. and Soviet influence against the background of the region as the world's leading oil producer. Mr. Smolansky.

41. Science, Technology and International Relations (3) P
Survey of the international dimensions of several large-scale technologies and scientific fields—marine science and engineering, weather modification, genetic engineering, aspects of environmental controls, communication satellites, remote sensing satellites-in order to assess their consequences for the international political system. Mr. Slouka.

47. Transnational Relations and World Politics (3) P
Analytic and evaluative survey of nongovernmental institutions and processes cutting across national boundaries. Prerequisite: I.R. 1 or 2 or consent of chairman. Messrs. Slouka and Hodges.

51. American Foreign Policy Since 1945 (3) P
Analysis of postwar American foreign policy from the Cold War to the rise of detente. Detailed examination of Kissinger-Nixon policy to show how changing international conditions affect the premises, concepts, and objectives of U.S. policy. Mr. Joynt.

95. Ideology in World Affairs (3) P
Role of ideology in international affairs: nature and function of ideology; pervasiveness of nationalism; distinctive ideologies of global regions; impact of ideology on foreign policies of states; role of ideology in transnational relations; recent global trends in ideology; and future of ideology in world affairs. Mr. Wylie.

101. The Politics of European Integration (3) U
The integration process in contemporary West Europe; the European Communities as examples of peaceful community-building at the supranational level. Institutional development of the European Communities and the political, economic and social dynamics of regional integration in West Europe. Prerequisite: I.R. 1 or 2. Mr. Hodges.

133. The Diplomacy of Russia to 1945 (3) U
Growth and expansion of the Russian Empire; principles of Russian foreign policy and their specific applications under the Tsarist and Communist governments; interaction between domestic and foreign affairs. In the post-1917 period, Soviet efforts to survive in a "hostile capitalist environment." Mr. Smolansky.

134. The Diplomacy of Russia After World War II (3) U
Stalin's efforts to consolidate gains made during and after the War; the origins of the "cold war"; growing frictions within the Communist bloc (Eastern Europe and China) as encountered by Stalin and his successors; the nuclear arms race and the striving for detente against the background of the Soviet attempt to preserve and consolidate the regime. Mr. Smolansky.

For Advanced Undergraduates and Graduates

300. Apprentice Teaching in International Relations (3)

301. International Policy-Making (3) U
Policy-making processes in the contemporary world community; how assumptions and projections of future social and technological change shape international decisions of today. Prerequisite: I.R. 1 or 2 or consent of chairman. Mr. Slouka.

302. War and World Politics (3) U
Origins, onset, conduct and termination of war; behavioral, cultural and structural conditions associated with war; models and methods that identify causes of war. Mr. Joynt.

303. International Peace Studies (3) U
Analysis of contemporary peace studies, especially the contribution of the behavioral sciences to the management, institutionalization and control of conflict. Mr. Joynt.

304. The Multinational Corporation As An International Actor (3) U
Examination of the economic, political and social role of the multinational corporation in the international system, with special reference to the relations between multinational corporations and national governments. Prerequisite: I.R. 1 or 2. Mr. Hodges.

305. The Dynamics of Regional Integration (3) U
Evaluation of theories of regional integration, using evidence from past and present attempts at supranational community-building in West Europe, the North Atlantic area, and the developing countries in Latin America, Asia and Africa. Mr. Hodges.

311. World Affairs, 1919-1945 (3)
The structure and politics of the state system after World War I; ideals and realities of the League of Nations; rise of Germany, Japan and Italy to challenge the established order; analysis of the political and strategic background to appeasement; the international crises of the 1930s; the Second World War. Prerequisite: consent of chairman. Mr. Braddick.

312. World Affairs Since 1945 (3) U
The impact of World War II upon the state system; the Cold War and the development of bipolar international politics; the United Nations as an instrument for international order

and security; the decline of the colonial system and the emergence of new states; development of Communist China and Western Europe as new power centers; contemporary problems in international relations. Prerequisite: consent of chairman. Mr. Braddick.

313. (Rel. 313) Religion and International Affairs (3) U
Theological assessments of the nation-state, the role of power in international affairs, national sovereignty and internationalism, war, pacificism, and alternative methods of conflict-resolution. Mr. Eckardt.

321. China in World Politics (3) U
Bases of Chinese foreign policy; Maoist ideology and domestic politics; foreign policy institutions; state-to-state relations; role in international communism; policies in underdeveloped world; place in transnational relations; current and future problems. Mr. Wylie.

324. Asia in World Affairs (3) U
International relations of contemporary Asia: specialized studies of Chinese, Japanese and Indian foreign policies; triangular relationship between USA, China and USSR; problems of smaller Asian states; transnational relations in Asia; and impact of Asian regional system on world politics. Mr. Wylie.

332. Contemporary Soviet Policy in the Middle East (3) U
Analysis of the causes, interests, and motivations underlying Soviet policy in the region during the post-Stalin era. Activities of Khrushchev and Brezhnev are examined in the light of superpower relations, regional politics, and Russia's traditional interest in the Middle East. Mr. Smolansky.

334. The Soviet Union in World Affairs (3) U
An appraisal of the objectives, strategy and tactics of Soviet diplomacy, with particular emphasis upon Russia's status as one of the Great Powers, and upon contemporary Soviet-American relations and their backgrounds. Prerequisite: I.R. 134 or consent of department chairman. Mr. Smolansky.

341. International Relations (3) U
An examination of contemporary theories and basic concepts of world politics, with application to historic and current issues of international politics. Prerequisite: consent of department chairman.

342. International Relations (3) U
An examination of the role of force in international politics including an analysis of deterrence, limited war, arms control and disarmament problems and crisis diplomacy. Prerequisite: consent of department chairman.

353. International Institutions (3) U
Theory and function of the League of Nations and the United Nations with particular reference to the problems of peace and security; regional and functional organizations. Mr. Braddick.

354. The Atlantic Community (3) U
Political, cultural, and strategic influences on the relationship between Western Europe and the United States and Canada; NATO; strains in the Community and prospects. Mr. Braddick.

361. International Law (3) U
Foundation and structure of international law; sources of international legal rights and obligations; rules governing the coexistence, interaction, and conflict of states; and international lawmaking and adjudication. Mr. Slouka.

362. International Law (3) U
Function of international law in the world political process; rise and demise of international legal norms; social, political, economic, cultural, and technological forces shaping the world legal order. Mr. Slouka.

371. Readings in International Relations (3) U
Directed studies and readings in the several fields of international relations, designed for the student who has a special competence or interest in some area not covered by regularly rostered courses. May be repeated for credit. Prerequisite: consent of department chairman.

372. Readings in International Relations (3) U
Continuation of I.R. 371. May be repeated for credit. Prerequisite: consent of department chairman.

381. Special Topics (3) U
An intensive study of some aspects of international politics not covered in another course. Prerequisite: consent of department chairman.

382. Special Topics (3) U
A continuation of I.R. 381. Prerequisite: consent of department chairman.

391. The Teaching of International Relations (3) U
Lectures, readings and discussion of fundamental concepts, principles and problems of international relations, with current applications. Open only to present and prospective junior and senior high school teachers.

Management and Finance

Professors

James B. Hobbs, D.B.A., *Chairman*
Brian G. Brockway, LL.M., *Dean of the College of Business and Economics*
Eli Schwartz, Ph.D.
L. Reed Tripp, Ph.D.
Gary E. Whitehouse, Ph.D.

Associate Professors

Carl R. Beidleman, Ph.D.
John W. Bonge, Ph.D.
David S. Halfhill, Ph.D.
James E. Hansz, Ph.D.
Leon Elwood Krouse, Ph.D.
Benjamin Litt, Ph.D.

Assistant Professors

James A. Greenleaf, Ph.D.
Raymond L. Horton, D.B.A.
Bruce M. Smackey, Ph.D.
Seymour Traub, J.D.

Adjunct Professors

Harry A. Dower, LL.B.
Edward H. McGee, LL.B.

Instructors

Stephen G. Buell, M.A.
John L. Tucker, M.B.A.

Finance

Major in Business and Economics College

Required: 15 credits beyond the core listed on page 47, from the following:

Fin 323	Investments (3)
Fin 324	Security Analysis (3)
Fin 326	Problems in Financial Management (3)
Fin 330	Financial Flows and Markets (3)
Fin 331	Bank Management (3)
Fin (Eco) 332	Monetary-Fiscal Policy (3)
Fin (Eco) 340	International Finance (3)
Fin (Eco) 353	Public Finance: Federal (3)
Fin (Eco) 354	Public Finance: State and Local (3)
Fin 371	Directed Readings (1-3)
Fin 372	Special Topics (1-3)

For Advanced Undergraduates and Graduates

255. Business Finance (3) fall-spring
An introductory course in corporation finance which stresses the management approach as it applies to asset management and capital structure. Emphasis is placed on financial policies regarding the acquisition of funds and their allocation to competing assets within the firm. Problems are used to illustrate the principles involved. Prerequisites: Eco. 1 and Acctg. 51 or Acctg. 108.

300. Apprentice Teaching in Finance (1-3) fall-spring

323. Investments (3) spring
An introduction to the investment process. The nature of risk and the form of returns to financial assets are examined. Investor objectives, attitudes and constraints are considered in conjunction with the risk-return matrix as the basis for investment decisions. Problems of timing, market characteristics and portfolio management are also treated. Prerequisite: course in corporation finance. Mr. Krouse.

324. Security Analysis (3) fall
Examination of factors which influence the value of financial securities, including earnings forecasts and expectations, uncertainty, investor attitudes, required returns, and the supply and demand for securities and funds. Also considered are market factors, technical approaches, timing, screening, and portfolio implications. Prerequisite: a course in corporation finance. Mr. Beidleman.

326. Problems in Financial Management (3) spring
Consideration is given to the financial policies of management, with considerable emphasis placed on the corporation's relationship to government and the general economy. Prerequisite: a course in corporation finance.

330. Financial Flows and Markets (3) alternate years
The nature and role of financial intermediaries in financial markets from a flow-of-funds perspective. Emphasis is on the interrelationships between financial and non-financial flows in the economy, and the forecasting of interest rate structures. Prerequisite: junior standing.

331. Bank Management (3) alternate years.
The management of bank resources and assets within the framework of economic and legal constraints. Particular attention is given to optimizing the objectives of profitability, safety, and liquidity. Completion of a project in bank management is required of each student. Prerequisite: senior standing. Mr. Krouse.

332. (Eco. 332) Monetary-Fiscal Policy (3)
For course description, see Eco. 332.

340. (Eco. 340) International Finance (3)
For course description, see Eco. 340.

353. (Eco. 353) Public Finance: Federal (3)
For course description, see Eco. 353.

354. (Eco. 354) Public Finance: State and Local (3)
For course description, see Eco. 354.

371. Directed Readings (3)
A course of readings in various fields of finance, designed for the student who has a special interest in some field of finance not covered in scheduled courses. Prerequisite: consent of department chairman. May be repeated.

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

For Graduates

415. (Eco. 415) Capital and Interest Theory (3) alt. years
Examination of theories of interest and capital. The following topics are investigated: present value theory; investment valuation under certainty and risk; term structure of interest rates; the theory of savings, cost of capital, and capital formation. Prerequisite: consent of chairman. Mr. Schwartz.

421. Financial Management (3) fall-spring
A decision-oriented course which integrates the theory and practice of business finance. Among the topics included are working capital management, capital expenditure decisions, functions of the capital markets, mergers, dividend policy, capital structure, valuation and the cost of capital. The effect of uncertainty on the problems of financial analysis is considered. Readings, case problems and decision-oriented reports are utilized to illustrate the principles involved. Prerequisite: Fin. 225 and Eco. 129.

425. (Eco. 425) Public Finance (3)
For course description, see Eco. 425.

431. Advanced Investment Analysis and Portfolio Management (3) fall
This course is designed to integrate the theoretical and empirical aspects of the economic environment with the investment analysis associated with portfolio management programs of financial intermediaries and individuals. Particular emphasis is given in the course to the current impingements of the economic environment upon portfolio management decisions. Prerequisite: a course in investments. Mr. Krouse.

442. (Eco. 442) Foreign Trade Management (3)
For course description, see Eco. 442.

444. (Eco. 444) Banking and Monetary Policy (3)
For course description, see Eco. 444.

451. Quantitative Financial Models (3) alternate years
A survey of quantitative models as they relate to financial theory and applications. Finance topics include capital budgeting, portfolio selection, security evaluation, cash management, inventory policy and credit analysis. Prerequisite: consent of chairman. Mr. Greenleaf.

471. Directed Readings (1-3)
Graduate readings in finance not covered in regularly scheduled coursework. Prerequisite: consent of department chairman. May be repeated.

472. Special Topics (1-3)
Special problems and issues in finance for which no regularly scheduled graduate coursework exists. When offered as group study, coverage varies according to interests in finance. Prerequisite: consent of department chairman. May be repeated.

Law

Undergraduate Courses

101. Business Law (3) fall-spring
The law of sales contracts and product liability under the Uniform Commercial Code. A case and problems approach is used to develop analytic methods and research skills involved in the examination of numerous types of commercial transactions.

102. Business Law (3) spring
The law of negotiable instruments, bank deposits and collections, secured transactions, and business organizations (agency, partnerships, and corporations). Prerequisite: Law 101.

For Advanced Undergraduates and Graduates

211. Legal Concepts (3) alternate years
Study of legal reasoning, law as a process of resolving disputes; law as an instrument of social control; selected problems in ownership; provisions for the redress of harm; maintenance of law and order.

300. Apprentice Teaching in Law (1-3)

371. Directed Readings (1-3)
Readings in various fields of law, designed for students who have a special interest in a field of law not covered in regularly scheduled courses. Prerequisite: consent of department chairman. May be repeated.

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

For Graduates

401. Legal Problems in Business (3) fall-spring
Specific legal problems involved in making business decisions. Emphasis is placed on preventive law and the tax consequences of business transactions. Prerequisite: Law 101 or 102. Mr. Dower.

471. Directed Readings (1-3)
Graduate readings in law not covered in regularly scheduled courses. When offered as group study, coverage will vary ac-

cording to the interests of the instructor and students. Prerequisite: consent of department chairman. May be repeated.

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

Management

Major in Business and Economics College

Required: 15 credits beyond the core listed on page 47 from the following:

Required Courses

Mgt 302	Quantitative Models–Conceptual (3)
Mgt 321	Organization Behavior (3)

Electives

In addition, the management major must select one of the three options shown below. (An asterisk * denotes courses that are strongly recommended to be taken.)

Quantitative (select three courses)

*Mgt 304	Quantitative Models–Applications (3)
Mkt 312	Marketing Research (3)
Acctg 324	Cost Accounting (3)
Econ 352	Advanced Statistical Methods (3)

Behavioral (select three courses)

*Mgt 316	Organizational Decision Processes (3)
Mgt 331	Industrial Relations (3)
Mkt 220	Behavioral Aspects of Selling (3)
Mkt 315	Consumer Behavior (3)

General Management (select five courses)

Mgt 311	LUMAC (see below) (3)
*Mgt 316	Organizational Decision Processes (3)
*Mkt 319	New Product Planning (3)
*Fin 326	Problems in Financial Management (3)
Econ 346	Business Cycles and Forecasting (3)
Econ 333	Managerial Economics (3)

(Only the repeat taking of Mgt 311 may be counted toward the general management option. The initial taking of Mgt 311 will not be counted toward satisfying requirements of the general management option.)

For Advanced Undergraduates and Graduates

269. Management of Operations in Organizations (3) fall-spring
Study of the design, operation and control of activities necessary to generate the goods or services of profit and non-profit organizations. Includes examination of basic concepts and quantitative models used in operations. Consideration of constraints imposed by the organization's goals, nature of the materials, information for energy processed, existing technology and environmental risks.

270. Conceptual Foundations of Organizational Theory and Behavior (3) fall-spring
A study of formal organizations as on-going systems and the behavior of people within them. Systems examined include: a bureaucratic-rationality model; a behavioral-social model; and an adaptive-contingency model.

300. Apprentice Teaching in Management (1-3) fall-spring

301. Business Management Policies (3) fall-spring
A study of business problems and the formulation of policies to meet these problems from the viewpoint of general management, integrating knowledge acquired in other courses in order to develop skill in policy formulation for particular functions and for companies as a whole. Long-range goal attainment and the required administration actions will be emphasized. The course is supplemented by case studies, simulation games, and interactions with management of local industry. Prerequisite: senior standing in College of Business and Economics, and completion of the college core.

302. Quantitative Models–Conceptual (3) fall-spring
Survey course of various management science models and methods; mathematical programming, inventory, queueing, maintenance and replacement, simulation, PERT and CPM, line of balance, and game theory. Prerequisites: Eco. 45, Acctg. 111, and one semester of calculus. Mr. Greenleaf.

304. Quantitative Models–Applications (3) spring
Extension and application of selected topics covered in Mgt. 302. Development of term projects to solve practical problems. Prerequisite: Mgt. 302. Mr. Greenleaf.

311. LUMAC (Management Assistance Counselling) (3) fall-spring
A field studies course primarily for business and economics majors. Students acquire experience in accounting, financial control, marketing and management under the faculty's supervision by providing management assistance to small businesses in the Lehigh Valley. Students work in small groups on a direct basis with owners. Prerequisite: consent of department chairman. Course may be repeated once for credit.

316. Organizational Decision Processes (3) spring
Examination of the managerial decision-making processes in complex organizations. Consideration of variations in task (routine vs. non-repetitive, structured vs. unstructured) and variations in process emerging and environment (stable vs. unstable) on the management of teams. Primary focus on necessary inputs for organizational effectiveness. Prerequisite: Mgt. 269 or 270. Mr. Bonge.

321. Organization Behavior (3) fall-spring
Focus on three interpersonal processes that underlie most behavior interactions in work groups: (1) conflict behavior and modes of conflict resolution; (2) competitive behavior in individual and small groups; and (3) cooperative behavior (ritualistic and non-ritualistic). Prerequisite: Mgt. 270 (or a course in psychology). Mr. Litt.

331. Industrial Relations (3) fall
Interdisciplinary consideration of conflict and conflict resolution procedures in the industrial and related settings, emphasizing behavioral aspects of work roles in intergroup relationships, collective bargaining in private and public sectors, grievance machinery terminating in arbitration, mediation, fact-finding and other aspects of public emergency dispute settlement. Prerequisite: Mgt. 270. Mr. Tripp.

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 department chairman. May be repeated.

372. Special Topics (1-3)
Special problems and issues in management for which no regularly scheduled coursework exists. When offered as group study, coverage will vary according to interests of instructor and students. Prerequisite: consent of department chairman. May be repeated.

For Graduates

412. Organization Structures and Processes (3) spring
An examination of the structure and processes of organizations. The traditional bureaucratic model of managing work and information flow is contrasted with the behavioral decision-making model of the firm. A synthesis of these perspectives is sought through a study of the contemporary theory of organization. Classroom activity centers around the discussion of research-based theories and the analysis of case problems. Prerequisites: Mgt. 270 or a course in psychology. Mr. Bonge.

417. (I.E. 417) Advanced Mathematical Programming (3)
For description, see I.E. 417.

418. Analytical Methods in Management (3) alternate years
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. Prerequisite: Mgt. 302. Mr. Smackey.

430. (I.E. 430) Management Science Project (3)
As an individual or as a member of a small group, an analysis is made 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.

451. Managerial Policy and Decision-Making (3) fall-spring
Integration of theory and analytic techniques through intensive investigation of complex economic and financial problems in corporations. A case-study approach is used. Topics include economic and accounting cost analysis, price determination, demand forecasting, capital investment analysis, risk and uncertainty, and the economic evaluation of alternatives. Prerequisites: graduate-level exposure to accounting, economics, finance, management and marketing. An MBA candidate should take the course near the end of his or her MBA program. Mr. Hobbs.

471. Directed Readings (1-3)
Graduate readings in management not covered in regularly scheduled coursework. Prerequisite: consent of department chairman. May be repeated.

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 interest of instructor and students. Prerequisite: consent of department chairman. May be repeated.

Marketing

Major in Business and Economics College

Required: 15 credits beyond the core listed on page 47 from the following.

Required Courses

Mgt 302	Quantitative Models—Conceptual (3)
Mkt 312	Marketing Research (3)

Elective Courses

Three courses (9 credit hours) from the following:

Mkt 213	Marketing Communications (3)
Mkt 220	Behavioral Aspects of Selling (3)
Mkt 315	Consumer Behavior (3)
Mkt 317	Industrial Marketing (3)
Mkt 319	New Product Planning (3)
Mkt 371	Directed Readings (1-3)
Mkt 372	Special Topics (1-3)
Eco 339	International Trade (3)

For Advanced Undergraduates and Graduates

211. The American Marketing System (3) fall-spring
Examination and analysis of the contemporary marketing system within a conceptual and systems-oriented approach; as a social institution; specific marketing activities; and evaluation of its socioeconomic strengths and weaknesses.

213. Marketing Communications (3) alternate years
The purposes and effects of marketing communications including the formation, performance, and dissolution of channels of communications, and socioeconomic aspects. Prerequisite: Mkt. 211.

220. Behavioral Aspects of Selling (3) alternate years
Analysis and application of behavioral science concepts to the sales transaction. The role of personal selling in the total mix of available marketing communications is examined through case problems and field work. Prerequisite: Mkt. 211 and consent of chairman.

300. Apprentice Teaching in Marketing (1-3) fall-spring

312. Marketing Research (3) fall-spring
Use of quantitative and qualitative information in routine and non-recurring decision-making. Topics include 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: Mkt. 211 and Eco. 45.

315. Consumer Behavior (3) fall
Examination of principal theories which the fields of psychology, social psychology, anthropology, and economics contribute toward understanding the behavior and motivations of consumers. Topics include 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. 312 or consent of department chairman. Mr. Horton.

317. Industrial Marketing (3) spring
Analysis of marketing problems unique to manufacturers of industrial products. Focus on planning the product line, developing pricing strategies, analyzing buyer behavior, and managing customer relations. Case problems. Prerequisite: Mkt. 211 or equivalent background. Mr. Halfhill.

319. New Product Planning (3) spring
An advanced marketing course specializing in the organization and management of marketing activities related to the development of new and improved products. The role of marketing research and pre-production testing in the commercialization process. Application of simulation and risk analysis to the screening of research and development projects. Prerequisite: Mkt. 312 or consent of department chairman. Mr. Smackey.

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 department chairman. May be repeated.

372. Special Topics (1-3)
Special problems and issues in marketing for which no regularly scheduled coursework exists. When offered as group study, coverage will vary according to the interests of the instructor and students. Prerequisite: consent of department chairman. May be repeated.

For Graduates

420. Managing the Sales Effort (3)
Organizing and managing the sales staff, including selection, training, compensation, motivation, and supervision. Planning, executing, and controlling aspects are emphasized. Prerequisite: graduate coursework in marketing, or the equivalent. Mr. Halfhill.

450. Marketing Planning and Organization (3) fall
A graduate course in marketing with an emphasis on marketing planning, marketing organization, and the impact of information on marketing decision-making. Analytical examination of pricing, product, promotion, and distribution decision; development of competitive strategies. Mr. Hansz.

471. Directed Readings (1-3)
Graduate readings in marketing not covered in regularly scheduled courses. When offered as group study, coverage will vary according to the interests of the instructor and students. Prerequisite: consent of department chairman. May be repeated.

472. Special Topics (1-3)
Special problems and issues in marketing for which no regularly scheduled graduate coursework exists. When offered as group study, coverage will vary according to the interest of the instructor and students. Prerequisite: consent of department chairman. May be repeated.

Mathematics

Professors

Arthur Everett Pitcher, Ph.D., *Chairman and Distinguished Professor*
Edward F. Assmus, Jr., Ph.D.
Dominic G. B. Edelen, Ph.D.
Bhaskar Kumar Ghosh, Ph.D.
Theodore Hailperin, Ph.D.
Chuan-Chih Hsiung, Ph.D.
Samir Anton Khabbaz, Ph.D.
Jerry Porter King, Ph.D.
Gregory T. McAllister, Ph.D.
Gilbert Allan Stengle, Ph.D.
Albert Wilansky, Ph.D.

Associate Professors

Samuel Linial Gulden, M.A.
George E. McCluskey, Ph.D.
Gerhard Rayna, Ph.D.
Murray Schechter, Ph.D.
Andrew Kagey Snyder, Ph.D.
David Trutt, Ph.D.

Assistant Professors

Richard F. Basener, Ph.D.
Paul E. Cohen, Ph.D.
Donald M. Davis, Ph.D.
Paul L. Davis, Ph.D.
Bennett Eisenberg, Ph.D.
Gary Bernard Laison, Ph.D.
Clifford S. Queen, Ph.D.
Viswanatha Raja Gopala Rao, Ph.D.
Ruth Silverman, Ph.D.

Lecturer

Robert J. Frank, M.S.

Adjunct Lecturer

Richard J. Cichelli, B.S.

Mathematics is the universal language of science. The major in mathematics prepares the student to use mathematics for expressing and analyzing relationships in a wide variety of disciplines. These include the exact sciences, the social sciences, business and pure mathematics itself. The program emphasizes fundamental principles and the mastery of techniques required for the effective use of mathematics.

Special programs can be arranged for students interested in computer science, actuarial science, statistics, or applications to other sciences.

Required Preliminary Courses

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Math 23	Analytic Geometry and Calculus III (4)

or, in place of the three above, both of the following courses:

Math 31	Calculus (4)
Math 32	Calculus (4)

Required Major Courses

Math 205	Linear Methods (3)
Math 219	Principles of Analysis (3)
Math 220	Principles of Analysis (3)
Math 226	Complex Analysis (3)
Math 243	Algebra (3)
Math 244	Algebra (3)
	Major Electives (12)

Note: Approval of the electives by a designated representative of the department is required. They need not all be courses offered by the mathematics department. They must include at least one of the following: Math 307, 309, 320 and 331.

Students with an interest in applied mathematics are encouraged to choose for some of their major electives mathematically oriented 200- or 300-level courses offered by other departments.

Students interested in actuarial science are advised to include Math 309, 334, and either 230 or 231 among their major electives. For information on preparation for taking examinations of professional actuarial societies students may consult their mathematics advisor.

For students especially interested in Computer Science, the substitutions Math 208 for Math 226 and Math 317 for Math 244 will be acceptable. It is suggested that their electives include some or all of the following: Math 105, 331, 362, EE 241, and EE 315.

Minors in Mathematics

These are five minors offered in the department of mathematics. The courses normally required are listed below. For substitutions, consult the chairman of the department.

Minor in Pure Mathematics

Math 21, 22, 23, 219, 243, and 244
Math 220 or 226

Minor in Probability and Statistics

15 credits of mathematics, including at least three of the following:
Math 42 or 231 (only one accepted for credit)
Math 201
Math 309
Math 310
Math 334

Minor in Actuarial Science

Math 230 and 243
At least three of the following:
Math 231
Math 309
Math 310
Math 334

Minor in Computer Science

Math 21, 22, 23, 105, 205, and 362
Math 243 or 317

Minor in Astronomy

Physics 11, Math 21, and Astr 2
Math 22 or Readings (Math 171 or 371) approved by the division of astronomy
Astr 211 or 221
Astr 232 or 242

Undergraduate Courses

21. Analytic Geometry and Calculus I (4) PU fall-spring
Functions and graphs; limits and continuity; derivative and differential; indefinite and definite integral; logarithm and exponential.

22. Analytic Geometry and Calculus II (4) PU fall-spring
Trigonometric and hyperbolic functions; integration; vector algebra and calculus; solid analytic geometry. Prerequisite: Math. 21.

23. Analytic Geometry and Calculus III (4) PU fall-spring
Series; Taylor's Theorem; approximations; partial derivatives, multiple integrals; line and surface integrals; differential equations. Prerequisite: Math. 22.

Mathematics 31 and 32 is an accelerated calculus sequence which is equivalent to Mathematics 21, 22, and 23.

31. Calculus (4) PU fall
Functions and graphs; limits and continuity; derivative and differential; indefinite and definite integral; logarithm, exponential, trigonometric and hyperbolic functions; integration; vector algebra and calculus. Math. 31 may be used in place of Math. 21 to satisfy prerequisites. Prerequisite: consent of chairman of department.

32. Calculus (4) PU spring
Vector calculus; solid analytic grometry; series; Taylor's Theorem; approximations; partial derivatives; multiple integrals; line and surface integrals; differential equations. Math. 32 may be used in place of Math. 23 to satisfy prerequisites. Prerequisite: Math. 31.

Mathematics courses 41-44 are designed primarily for students of the Biological, Management, and Social Sciences.

41. BMSS Calculus (3) PU fall-spring
The Riemann integral, the derivative, limits and continuous functions, the mean value theorem, the fundamental theorem of the calculus, antiderivatives, applications of the integral, maxima and minima, infinite sequences and series, partial derivatives.

42 BMSS Probability (3) PU spring
Sets, functions, counting methods, probability spaces, conditional probability and independence, random variables, continuous probability spaces, some useful probability distributions—binomial, hypergeometric, Poisson, uniform, exponential and normal.

43. BMSS Linear Algebra (3) PU 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.

44. BMSS Calculus (3) PU fall-spring
Functions of several variables, applications of partial derivatives, extreme values of functions, Lagrangian multipliers, complex variables and exponentials, Euler's formula, calculus of trigonometric functions, linear difference and differential equations, systems of linear equations, numerical solution of differential equations. Prerequisite: Math. 41 or 21 or consent of department chairman.

81. Computers and Calculus (1) PU fall
Writing and testing digital computer programs to solve problems arising from the calculus. Designed for students enrolled in Math. 21, 31, and 41 who are not taking another introductory course in computing. No previous knowledge of programming is assumed. Prerequisite: Math. 21, 31, or 41, concurrently or previously.

82. Computers and Calculus (1) PU spring
A continuation of Math. 81. Prerequisite: Math. 81 or consent of chairman of department.

105. Computer Programming (3) PU fall-spring
The translation of simple mathematical and logical problems into forms permitting their solution by digital computers, with emphasis on machine-language programming of several typical types of computers. Mr. Rayna.

110. (I.S. 110) Algorithmic Processes (3) P
The role of machines as physical models of abstract processes. Computability, practical computability, and unsolvability. Examples drawn from pure mathematics including recursive function theory and the real number system. Prerequisite: Math. 23 or Math. 32. Mr. Barnes.

171. Readings (1-3) PU 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 department chairman. May be repeated for credit.

For Advanced Undergraduates and Graduates

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 semester-hours of calculus.

201. Mathematical Models in the Social Sciences (3) PU fall
Construction and analysis of models chosen from psychology, biology, sociology, economics, government and business. Mathematical techniques used may include differential equations, axiomatics, Markov chains, branching processes, graph theory, and dynamic programming. Prerequisites: Math. 42 and 44 or consent of department chairman. Mr. Eisenberg.

205. Linear Methods (3) PU fall-spring
Matrices; systems of linear equations; determinants and rank; characteristic roots; linear differential equations; eigenvalue problems; analytic functions; Bessel's equation. Designed for undergraduates in science and engineering. Prerequisite: Math. 23 or Math. 32.

208. Complex Variables (3) PU fall-spring
Functions of a complex variable; calculus of residues; contour integration; applications to conformal mapping and Laplace transforms. Prerequisite: Math. 23, Math 32, or nine semester hours of differential and integral calculus.

219. Principles of Analysis I (3) PU fall-spring
The real number system; limits; continuous functions; differ-

entiation; integration; infinite series. Prerequisite: Math. 23, Math. 32 or nine semester hours of differential and integral calculus.

220. Principles of Analysis II (3) PU fall-spring
Continuation of Math. 219. Absolute and uniform convergence; functions of several variables; line and surface integrals; implicit functions. Prerequisite: Math. 219.

226. Complex Analysis (3) PU spring
A self-contained survey of the fundamentals of complex analysis. The concept of analytic function from the points of view of the Cauchy-Riemann equations, power series, complex integration and conformal mapping. Prerequisite: Math. 219.

230. Numerical Methods (3) PU fall
Numerical solution of non-linear equations and systems; linear systems and the algebraic eigenvalue problem; difference calculus and interpolation; numerical differentiation and quadrature; numerical solution of ordinary differential equations. Students will use a digital computer. Prerequisite: Math. 205. Messrs. Rao and Schechter.

231. Probability and Statistics (3) PU fall-spring
Probability and distribution of random variables; populations and random sampling; t, chi-square, and F distributions; estimation and tests of hypotheses; correlation and regression theory of two variables. Prerequisite: Math. 23, Math. 32, or nine semester hours of calculus.

243. Algebra (3) PU fall-spring
An introduction to the basic concepts of modern algebra beginning with group theory and including ring theory, linear algebra, and field theory. Prerequisite: Math. 205.

244. Algebra (3) PU fall-spring
A continuation of Math. 243. Prerequisite: Math. 243.

251. Mathematical Methods (1-4) PU
An introductory survey of topics in analysis for graduate students in fields other than mathematics. Topics may include: differential equations, techniques of series expansion, numerical methods, matrix and vector analysis, complex variables, calculus of vector fields. Formal applications are emphasized. Prerequisites: graduate standing and consent of the chairman. With consent of the department chairman, may be repeated for credit.

285. Introduction to Geometries (3) PU fall
Introduction to synthetic and analytic projective geometry with emphasis on Euclidean and non-Euclidean geometries as special cases. Some familiarity with matrices and determinants is desirable.

301. Vector and Tensor Analysis (3) PU spring
Elementary vector identities. Gauss's theorem and Stokes's theorem. Elementary differential geometry of curves and surfaces. Calculus of tensors. Prerequisite: Math. 23 or Math. 32 or nine semester hours of differential and integral calculus.

303. Mathematical Logic (3) PU fall
A course, on a mathematically mature level, designed not only to acquaint the student with the logical techniques used in mathematics but also to present symbolic logic as an important adjunct in the study of the foundations of mathematics. Messrs. Cohen and Hailperin.

304. Axiomatic Set Theory (3) PU 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 department chairman. Messrs. Cohen and Hailperin.

307. General Topology I (3) PU 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.

308. Algebraic Topology I (3) PU spring
Polyhedra, fundamental groups, simplicial and singular homology. Prerequisites: Math. 307 and Math. 327.

309. Theory of Probability (3) PU fall-spring
Probabilities on discrete and continuous sample spaces; events on a discrete sample space; random variables and probability distributions; transformations; simplest kind of law of large numbers and central limit theorem. The theory will be applied to problems in physical and biological science. Prerequisite: Math. 23, Math. 32, or nine semester hours of differential and integral calculus. Mr. Ghosh.

310. Probability and its Applications (3) PU spring
Continuation of Math. 309. Random variables, characteristic functions, limit theorems; stochastic processes, Kolmogorov equations; Markov chains, random walks; time series. Prerequisite: Math. 309 or consent of department chairman. Messrs. Eisenberg and Ghosh.

317. (E.E. 317, I.E. 317) Analytical Methods for Information Sciences (3)
For description, see E.E. 317.

320. Ordinary Differential Equations (3) PU spring
The analytical and geometric theory of ordinary differential equations, including such topics as linear systems, systems in the complex plane, oscillation theory, stability theory, geometric theory of non-linear systems, finite difference methods, general dynamical systems. Prerequisites: Math. 220 previously or concurrently and Math. 205.

322. Methods of Applied Analysis I (3) PU fall-spring
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 chairman of department.

323. Methods of Applied Analysis II (3) PU spring
Green's functions; integral equations; variational methods; asymptotic expansions, method of saddle points; calculus of vector fields, exterior differential calculus. Prerequisite: Math. 322.

327. Groups and Rings (3) PU fall
An intensive study of the concepts of group theory including the Sylow theorems, and of ring theory including unique factorization domains and polynomial rings.

331. Numerical Analysis (3) PU spring
Examination of some commonly used numerical methods for the solution of linear and non-linear equations, quadrature, and the solution of ordinary differential equations. Special attention is given to the analysis of errors resulting from rounding, discretization, and truncation. The course work involves the use of a digital computer. Prerequisite: Math. 219.

333. Difference Methods for Partial Differential Equations (3) PU
Maximum principles; theory of characteristics; construction of convergent and stable difference schemes; error analysis; variational techniques; iterative methods; Von Neumann's stability criterion; eigenvalue problems. Prerequisite: consent of department chairman. Mr. Davis.

334. Mathematical Statistics (3) PU fall
Populations and random sampling; sampling distributions; theory of statistical estimation; criteria and methods of point and interval estimation; theory of testing statistical hypothesis; analysis of variance; non-parametric methods. Prerequisite: Math. 309 or consent of the department chairman. Mr. Ghosh.

342. Number Theory (3) PU
A survey of elementary and non-elementary 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 department chairman. Mr. Queen.

350. Special Topics (3) PU
A course covering special topics not sufficiently covered in the general courses. Prerequisite: consent of department chairman. May be repeated for credit.

361. (I.S. 361) Automata and Formal Grammars (3)
For description see I.S. 361.

362. Computer Languages (3) PU fall
An examination of a number of high-level computer programming languages, and of the concepts and techniques which are used in the design of the compilers which translate them. Prerequisite: Math. 105 or consent of department chairman. Mr. Rayna.

371. Readings (3) PU
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 chairman of the department. May be repeated for credit.

381. Probability and Statistics (3)
Combinatorial problems, theory of probability, various frequency distributions, standard deviation, sampling, correlation. Prerequisite: open to secondary school teachers who present at least eighteen hours of undergraduate mathematics.

382. Algebra (3)
Fundamentals of algebra, axiomatic method, set theory, notions of group, ring, integral domain, and field. Prerequisite: same as Math. 381.

385. Higher Geometry I (3)
Logical systems, postulates, synthetic projective geometry, analytic projective geometry, affine, euclidean and non-euclidean geometry. Prerequisite: same as Math. 381.

387. Intermediate Analysis (3)
The real number system, functions, limits, continuity, derivative, law of the mean, Taylor's formula, definite integral. Prerequisite: open only to secondary school teachers of mathematics who present at least 18 semester hours of undergraduate mathematics including a course in analysis.

For Graduates—Mathematical Program

The department of mathematics offers a graduate program in mathematics leading to the Ph.D. degree. The first of these degrees was awarded in 1939. In the fall of 1974 there were about fifty graduate students of mathematics, of whom about twenty-five were engaged in writing Ph.D. theses. The M.S. degree in mathematics may be taken as a final degree or as an incidental step on the road to a Ph.D. degree.

To begin graduate work in mathematics, a student must present evidence of adequate study of mathematics as an undergraduate. The program should have included at least a year of advanced calculus, a semester of linear algebra, and a semester on groups, rings, and fields.

The program for the M.S. degree will ordinarily include Math. 307, 308, 327, 401, 415, 423, 428. A student with unusually strong background, or specialized interests, may be permitted to make substitutions.

The M.S. degree requires either a thesis or a comprehensive examination at the discretion of the department chairman. The same examination is used as the comprehensive examination for the M.S. degree and the qualifying examination for the Ph.D. degree. Thus it is usually required for the M.S. degree for those students who plan to continue to the Ph.D. A syllabus for the examination is available.

The plan of work for the Ph.D. degree will ordinarily include courses in algebra, analysis, geometry, and topology at the 400 level and several courses including seminars in the field in which the dissertation is to be written. The department accepts candidates for the Ph.D. who wish to specialize

in and to write a dissertation on some aspect of any of the following areas of advanced work: analysis with emphasis on pure mathematics or applied mathematics, algebra, functional analysis, differential geometry, mathematical logic, probability, statistics, and topology.

One may wish to refer to the description of the Center for the Application of Mathematics, page 73.

For Graduates - Computer Science Program

With the cooperation of several other departments, the department of mathematics also offers a program leading to the degree of M.S. in Computer Science.

To begin work in this program, the student must have some skill in programming in a computer language such as FORTRAN, ALGOL, BASIC, APL, or WIZARD, and some familiarity with the concepts of machine or assembly languages. (Math. 105 can be taken, without graduate credit, to remedy deficiency in these areas.) The student also must present at least two years of college mathematics.

The program must include the following four "core courses," except as competence in the respective areas results from past courses, experience, or is demonstrated otherwise:

Math 317	Analytical Methods for Information Sciences (3)
Math 362	Computer Languages (3)
EE 241	Switching Theory and Logic Design (3)
IE 310	File Structure and Processing (3)

The student's program is to be developed in consultation with a departmental advisor, and approved by an interdepartmental committee.

Further information can be found in a brochure available from the department.

401. Real Analysis I (3) fall
Spaces of continuous functions; the Lebesgue integral; differentiation; general theory of measure and integration; Banach and Hilbert spaces; *Lp*-spaces. Applications to such topics in classical analysis as integral equations and Fourier series. Prerequisite: Math. 307 or consent of chairman.

402. Real Analysis II (3) spring
Continuation of Math. 401. Prerequisite: Math. 401.

404. Mathematical Logic (3) spring
Advanced topics in quantification theory relevant to formalized theories, recursive functions, Godel's incompleteness theorem; algorithms and computability. Prerequisite: Math. 303. Messrs. Cohen and Hailperin.

405. Partial Differential Equations (3) fall
Classification and transformation of equations; theory of characteristics; initial and boundary value problems; Cauchy's problem for hyberbolic equations; Dirichlet's problem for elliptic equations; potential theory; Green's function; harmonic and sub-harmonic functions; difference equations; applications to equations of physics. Prerequisite: Math. 220.

406. Partial Differential Equations (3) spring
Continuation of Math. 405. Prerequisite: Math. 405.

407. Transforms (3) fall
The properties and use of the Fourier transform, the Laplace transform, the finite transform and generalized functions. Prerequisites: Math. 220 and either Math. 208, Math. 226, or Math. 415.

409. Mathematics Seminar (3 or 6) fall
An intensive study of some field of mathematics not offered in another course. Prerequisite: consent of department chairman.

410. Mathematics Seminar (3 or 6) spring
Continuation of the field of study in Math. 409 or the intensive study of a different field. Prerequisite: consent of department chairman.

415. Complex Function Theory (3) fall
An intensive study of the theory of analytic functions of one complex variable emphasizing the following topics: the Cauchy theory, representation theorems for analytic functions, the geometric theory, analytic continuation and Riemann surfaces. Prerequisite: consent of the chairman.

416. Complex Function Theory (3) spring
Continuation of Math. 415. Prerequisite: Math. 415 or consent of chairman.

419. Linear Operators in Hilbert Space (3) fall
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 emphasized. Prerequisite: Math. 220, and Math. 208 or 226 or 415. Mr. Trutt.

423. Differential Geometry I (3) fall
The differential geometry of curves and surfaces in Euclidean space, including problems in the large. Mr. Hsiung.

424. Differential Geometry II (3) spring
Multilinear algebra; differentiable manifolds; tensor bundles; exterior differential forms; theorems of Stokes and Frobenius; imbedding theorem; affine connections; holonomy groups; Riemannian manifolds. Prerequisites: Math. 423 and Math. 308. Mr. Hsiung.

425. Differential Geometry III (3) fall
Continuation of Math. 424. Curvature tensor; manifolds of constant curvature; Gauss-Bonnet formula; completeness; harmonic forms; curvature and homology; infinitesimal transformations; conjugate points and Morse index theorem; Lie groups and Lie algebras. Prerequisite: Math. 424. Mr. Hsiung.

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.

431. Calculus of Variations (3)
Fundamental existence theorems; necessary conditions and sufficient conditions for relative minima of single integrals;

the index theorem; application to boundary value problems. Prerequisite: Math. 401. Messrs. McAllister and Pitcher.

435. Functional Analysis I (3) fall
Linear topological spaces; local convexity; function spaces; inductive and weak topologies; duality, separation and extension theorems; the open mapping and uniform boundedness principles; Banach algebras; applications to classical analysis. Prerequisite: Math. 307. Mr. Wilansky.

436. Functional Analysis II (3) spring
Continuation of Math. 435. Prerequisite: Math. 435. Mr. Wilansky.

443. General Topology II (3) spring
A 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) fall
Continuation of Math. 308. Cohomology theory, products, duality. Prerequisite: Math. 308.

445. Algebraic Topology III (3) spring
Homotopy theory, obstruction theory, spectral sequences. Prerequisite: Math. 444.

449. Advanced Topics in Algebra (3)
An intensive study of some topics in algebra with emphasis on recent developments. May be repeated for credit. Prerequisite: consent of department chairman.

451. Measure Theory (3)
Contents chosen from such topics as: ergodic theory; measure on topological spaces; harmonic analysis on groups; invariant measures on transformation groups. May be repeated for credit. Prerequisite: Math. 402.

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. Algebraic Number Theory (3)
Ideal theory, Diophantine equations, theory of locally compact fields, p-adic numbers, and cyclotomic fields. Prerequisites: Math. 327 and 415, or consent of chairman. Mr. Queen.

456. Algebraic Number Theory (3)
Continuation of Math. 455, with emphasis on class field theory and analytic number theory. Prerequisite: Math. 455. Mr. Queen.

457. Summability (3)
Methods of generalization of the limiting process with classical applications. Applications of functional analysis. FK spaces. May be repeated for credit. Prerequisite: consent of chairman.

461. Mathematical Statistics (3)
An intensive study of one or more topics not sufficiently covered in Math. 334, such as theory of statistical tests, statistical estimation, regression and analysis of variance, nonparametric methods, stochastic approximation, decision theory. Prerequisites: Math. 334 and Math. 401. Mr. Ghosh.

463. Probability Theory (3)
An intensive study of one or more topics not sufficiently covered in Math. 309 or Math. 310, such as limit theorems, Markov processes, ergodic theorems, martingales, time series, stochastic integrals, potnetial theory. Prerequisites: Math. 310 and Math. 401. Mr. Eisenberg.

471. Homological Algebra (3)
Modules, tensor products, categories and functors, homology functors, projective and injective modules. Prerequisite: Math. 428.

472. Finite Groups (3)
An intensive study of the structure of finite groups and their automorphisms. Prerequisite: Math. 428.

Division of Astronomy

Associate Professor

George E. McCluskey, Ph.D.

1. The Solar System (3) fall
A survey of our knowledge of the solar system.

2. Stellar Astronomy (3) spring
Survey of our knowledge of stars and stellar systems.

211. Stellar Structure and Evolution (3) fall, even-numbered years
Physical processes in stellar interiors. Theory of stellar evolution and interpretation of observations. Prerequisite: Math. 23 or 32, previously or concurrently, and Phys. 21.

221. Stellar Atmospheres (3) fall, odd-numbered years
Theory of stellar spectra. Equation of transfer, model atmospheres, chemical abundances. Prerequisites: Math. 23 or 32, previously or concurrently, and Phys. 21.

232. High Energy Astrophysics (3) spring, odd-numbered years
Relativistic plasmas, x-ray sources, quasars, pulsars, radio galaxies, origin and evolution of the universe, current research. Prerequisites: Math. 23 or 32, previously or concurrently, and Phys. 21.

242. Relativity and Cosmology (3) spring, even-numbered years
Introduction to tensor analysis. Einstein's field equations,

origin and evolution of the universe, current research. Prerequisites: Math. 23 or 32, previously or concurrently, and Phys. 21.

Mechanical Engineering and Mechanics

Professors

Ferdinand Pierre Beer, Ph.D., *Chairman*
Russell Edward Benner, Ph.D.
Philip Anthony Blythe, Ph.D.
Forbes Taylor Brown, Sc.D.
John C. Chen, Ph.D.
Fazil Erdogan, Ph.D.
Thomas Edgar Jackson, M.S.
Arturs Kalnins, Ph.D.
Jerzy Antoni Owczarek, Ph.D.
Ronald S. Rivlin, Ph.D., *Centennial University Professor, Director, Center for Application of Mathematics*
George C. M. Sih, Ph.D., *Director, Institute for Fracture and Solid Mechanics*
Gerald Francis Smith, Ph.D.
Eric Varley, Ph.D.
Robert Peh-Ying Wei, Ph.D.

Associate Professors

Ronald John Hartranft, Ph.D.
Peter D. Hilton, Ph.D.
Edward Kenneth Levy, Ph.D.
Robert Alan Lucas, Ph.D.
Alister Kenneth Macpherson, Ph.D.
Joseph C. Osborn, M.S.
Richard Roberts, Ph.D.
Donald O. Rockwell, Ph.D.
Eric P. Salathe, Ph.D.
Robert Guy Sarubbi, Ph.D.
Theodore Alfred Terry, Ph.D.
Dean Pearson Updike, Ph.D.

Assistant Professors

Kemal Arin, Ph.D.
Tony Chen, Ph.D.
Stanley H. Johnson, Ph.D.

Visiting Professor

Vedanth Kadambi, Ph.D.

Instructor

Fahri T. Ozkaynak, Ph.D.

The curriculum in mechanical engineering and engineering mechanics consists of common freshman, sophomore, and junior years, and a senior year offering a wide selection of courses. Depending upon the program chosen during the senior year, the students are graduated with either the bachelor of science in mechanical engineering or the bachelor of science in engineering mechanics.

The core of the program includes courses in mathematics and the physical sciences, in mechanics of solids and fluids, in dynamics, vibrations analysis, thermodynamics, and design. Candidates for the bachelor of science in mechanical engineering take an additional course in thermodynamics and are required to take at least two professional mechanical engineering courses during their senior year. They should use the technical electives to develop competence in design, system analysis and control, stress analysis, thermofluid sciences, power engineering, or some other approved area. Candidates for the B.S. in engineering mechanics must include in their program advanced courses in mathematics, dynamics and mechanics of continua. They should use the technical electives to develop additional competence in a related area, such as applied mathematics, thermofluid sciences, or materials science.

The field of mechanical engineering is wide and challenging. Conventionally mechanical engineering deals with the design and production of machines and their power sources, but the field has broadened to include many applications of the engineering sciences to a variety of engineering systems for the benefit of mankind. The mechanical engineer has played an essential role in the exploitation of new engineering frontiers such as nuclear power, cryogenic systems, rocketry, satellite guidance systems, and systems at very high and very low pressures and temperatures. Mechanical engineers are also heavily involved in solving problems of pollution control and waste disposal.

On the other hand, there is an increasing demand in industry and government service for men with a broad training in the fundamentals of engineering rather than in a given specific field. Such training, in which applied mathematics and mechanics play an important part, is provided by the engineering mechanics option of this curriculum. This option emphasizes the analytical approach to engineering problems and the application to their solution of the basic methods and principles of mechanics.

Graduates in either discipline are equipped for immediate work in engineering or research and development in government service or industry. Those with ability and interest have suitable backgrounds for further studies at the graduate level.

Because of the flexibility of the curriculum, candidates for either degree may combine the study of mechanical engineering or engineering mechanics with that of other fields, such as chemical engineering, materials science, and biology, into interdisciplinary programs which will prepare them for further work in the areas of nuclear engineering, environmental engineering, materials science, or biomechanics.

Freshman Year (See page 52)

Sophomore Year, First Semester (17 credit hours)

Math 23	Analytical Geometry & Calculus III (4)
Mech 1	Statics (3)
Phys 21, 22	Introductory Physics II & Lab (5)
ME 12	Engineering Drawing and Descriptive Geometry (2)
	GS Requirement (3)

Sophomore Year, Second Semester (17 credit hours)

Math 205	Linear Methods (3)
ME 104	Thermodynamics I (3)
Mech 11	Mechanics of Materials (3)
Mech 13	Materials Testing Laboratory (1)
Met 91	Elements of Materials Science or
Met 63	Engineering Materials (3)
Eco 1	Economics (4)

Junior Year, First Semester (16 credit hours)

ME 101	Mechanical Engineering Design (1)
Mech 102	Dynamics (3)
ME 105	Thermodynamics II or
	Approved Elective (3)
ME 231	Fluid Mechanics (3)
Math 208	Complex Variables or
Math 231	Probability and Statistics (3)
	GS Requirement (3)

Junior Year, Second Semester (17 credit hours)

ME 102	Mechanical Engineering Design (2)
Mech 203	Advanced Strength of Materials (3)
CE 123	Fluid Mechanics Lab (1)
ME 242	Mechanical Vibrations (3)
EE 160	Introduction to Electrical Engineering (4)
EE 162	Electrical Laboratory (1)
	Elective (3)

Summer

ME 100	Industrial Employment

Senior Year, First Semester (14-17 credit hours)

ME 108	Laboratory I (2)
	Approved Electives (9)
	GS Requirement (3)
	Elective (0-3)*

Senior Year, Second Semester (14-17 credit hours)

ME 109	Laboratory II (2)
	Approved Electives (9)
	GS Requirement (3)
	Elective (0-3)*

*Please refer to description of normal program, page 52.

Note: In their junior year, candidates for the bachelor of science in mechanical engineering take M.E. 105; candidates for the bachelor of science in engineering mechanics take Math. 208.

The approved electives must represent a coherent group of approved courses such as 200- and 300-level courses in mechanical engineering and mechanics, as well as mathematics, physics, chemistry and a limited number of other fields. For candidates for the bachelor of science in mechanical engineering, six hours of approved electives are required in mechanical engineering and at least six more in mechanical engineering or mechanics. For candidates for the bachelor of science in engineering mechanics, the following courses are required: Mech. 302, Advanced Dynamics; Mech. 305, Advanced Mechanics of Materials; Mech. 307, Mechanics of Continua; and Math. 322, Methods of Applied Analysis I.

Mechanical Engineering

Undergraduate Courses

12. Engineering Drawing and Descriptive Geometry (2) fall
Engineering drawing, including sketching, machine operations, dimensioning, and tolerancing; detail and assembly drawings. Elements of descriptive geometry.

100. Industrial Employment (0)
Usually following the junior year, students in the mechanical engineering or engineering mechanics curriculum are expected 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.

101. Mechanical Engineering Design I (1) fall
Objectives and specifications are developed for design projects to be carried out in the second semester. Alternative design concepts are proposed and oral and written reports of feasibility studies are presented.

102. Mechanical Engineering Design II (2) spring
A continuation of M.E. 101 in which groups are organized to do preliminary design on a previously defined project. Program organization techniques are used and laboratory testing and data acquisition are carried out as needed to promote design development. Prototypes are constructed and tested, when practical. Prerequisites: M.E. 101, Mech. 11, M.E. 104.

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. Prerequisites: Math. 23, Phys. 11.

105. Thermodynamics II (3) fall-spring
Equations of state, non-reacting and reacting mixtures, combustion, equilibrium of mixtures both reacting and non-reacting, statistical thermodynamic concepts. Compressible flow. Prerequisite: M.E. 104.

108. Laboratory I (2) fall
Lectures and laboratory exercises relating to various phases of engineering laboratory technique and procedures. Includes planning, execution, and analysis of tests and writing of reports. Prerequisite: M.E. 105.

109. Laboratory II (2) spring
Continuation of M.E. 108 with emphasis on project investigations.

110. Thesis (1-3) fall-spring
Candidates for the degree of bachelor of science in mechanical engineering may, with the approval of the director of the curriculum, undertake a thesis as a portion of the work during the senior year.

166. Procedures for Mechanical Design (2) spring
General design procedures, motion analysis, force analysis, static, repeated and impact types of loading, modes of failure, stress analysis, failure theories. Applications to the design of typical machine elements. Prerequisite: Mech. 11.

For Advanced Undergraduates and Graduates

231. Fluid Mechanics (3) fall-spring
Fundamental concepts. Physical similarity. Kinematics of fluid flow. Equations of flow in integral form. Equations of flow of perfect fluids. Plane irrotational flow of incompressible fluids. Navier-Stokes equation; hydrodynamic stability; turbulence. Two-dimensional boundary layers in incompressible flows; separation of flow; wakes; drag. Effects of compressibility on fluid flow. Hydraulic treatment of losses in flows in ducts. Flows with free surface. Basic measurements techniques. Prerequisite: Math. 205.

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 or 103, Math. 205.

310. Projects (1-6) 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. 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 department chairman.

312. Synthesis of Mechanisms (3) spring
Geometry and constrained plane motion with application to linkage design. Type and number synthesis. Comparison of motion analysis by graphical, analytical and computer techniques. Euler-Savery and related curvature techniques as applied to cam, gear and linkage systems. Introduction to the analysis of space mechanisms. Prerequisites: Math. 205, Mech. 102. Mr. Terry.

320. Thermodynamics III (3) fall
Advanced treatment of thermodynamic laws both for single element and mixtures. Phase equilibrium. Ideal solutions, chemical equilibrium. Thermodynamic cycle analysis, real fluid properties, availability. Prerequisite: M.E. 104. Mr. Macpherson.

321. Introduction to Heat Transfer (3) fall-spring
Analytical, numerical, and analog solutions to steady and transient, one- and two-dimensional conduction problems; thermal radiation, free and forced convection of laminar and turbulent character inside cylindrical tubes and over external surfaces; thermal design of heat exchangers. Prerequisites: M.E. 104, M.E. 231. Messrs. J. Chen and Levy.

322. Gas Dynamics (3) spring
Equations of flow of compressible fluids. Thermodynamic properties of gases. Shock waves. One-dimensional steady flow through ducts with variable cross-sectional area, flows with viscous friction and heat addition. Prerequisites: M.E. 231, M.E. 104, Math. 205. Messrs. Owczarek and Rockwell.

324. Aerospace Propulsion Systems (3) spring
Cycle analysis of air-breathing engines. Optimum configurations for different flight regimes. Chemical and nuclear rocket engines. Component design. Prerequisite: M.E. 105. Mr. Jackson.

325. Vehicular Propulsion Systems (3) fall
Thermal analysis of internal combustion engines for vehicular propulsion. Component design. Unconventional propulsion systems. Applications to current problems in ground transportation. Prerequisite: M.E. 105. Mr. Jackson.

331. Fluid Mechanics (3) fall
Kinematics of fluid flow. Conservation equations for inviscid and viscous flows; integral forms of equations. Two-dimensional potential flow theory of incompressible fluids with applications. Boundary layers. Introduction to free shear layer and boundary layer stability and structure of turbulence. Transition from laminar to turbulent boundary layers. Separation of flow. Steady and unsteady stall. Secondary flows. Flow of non-Newtonian fluids. Hydrodynamic lubrication. Measurement techniques. Prerequisite: M.E. 231 or equivalent preparation. Messrs. Owczarek and Rockwell.

340. Advanced Mechanical Engineering Design (3) spring
Optimum design of mechanical components and systems. Parameter optimization by the theory of maxima and minima, geometric programming and optimum seeking methods. Automated design. Probabilistic approaches to design. Prerequisite: Math. 231. Mr. Benner.

341. Mechanical Systems (3) fall
Methods for the analysis and design of machine elements such as springs, gears, clutches, brakes, and bearings. Design for strength, motion and dynamic response objectives is emphasized. Case studies are presented which demonstrate the synthesis of elements into mechanical systems and the inte-

gration of associated analytical methods into rational design procedures. Prerequisites: Mech. 203 and M.E. 242. Messrs. Benner and Lucas.

342. Dynamics of Engineering Systems (3) fall
Dynamic analysis of mechanical, electromechanical, fluid and thermal engineering systems with emphasis on the modeling process. Survey of numerical methods with emphasis on dynamic simulation and computer practice. Prerequisite: M.E. 242. Mr. Johnson.

343. Control Systems (3) fall-spring
Linear analysis of mechanical, hydraulic, pneumatic, thermal and electrical feedback control systems. Transient and frequency response, root locus, stability criteria and compensation techniques. Prerequisites: Math. 205 and M.E. 242. Messrs. Brown, Johnson and Sarubbi.

350. Special Topics (1-3)
A study of some field of mechanical engineering not covered in the general courses. Prerequisite: consent of department chairman.

360. (Ch.E. 360) Nuclear Reactor Engineering (3) fall-spring
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 engineering or physical science. Messrs. J. Chen and Clump.

For Graduates

In the thermofluid sciences research is in process on a variety of problems involving fluid mechanics and heat transfer. Investigation continues on basic fluid phenomena with special emphasis being given to the area of fluidics including work on wall jets, confined jets, jet interaction and jet stability. In addition studies of the dynamics of fluid amplifiers, transmission line characteristics, noise and modeling of fluid amplifiers are under way. Geophysical fluid dynamics involving weather prediction, atmospheric shear layers, and tornadoes also are being investigated. A specially designed water table has been constructed to investigate fluid amplifier dynamics and experiments on plexiglas models are being conducted to determine velocity profiles and pressure distributions in wall jets on curved walls. Oscillatory flows are being studied in conical diffusers. In the area of heat transfer, both experimental and analytical research is being pursued on heat pipes, fluidized bed heat exchangers, fluidized combustors, multiphase flow systems, boiling heat transfer equipment, and solar heating and cooling systems. Equipment available for research includes a two-phase loop, a water tunnel, several fluidized bed facilities, a six-inch interferometer, a wind tunnel, and a heat pipe flow loop.

The department is well equipped for experimental stress investigations including instrumentation for research with resistance strain gages, photo-elasticity, photostress, and Moire fringes. Recent investigations have been made on viscoelastic materials as well as metals. Research in crack propagation and fatigue is under way which involves the interaction of students and faculty of the department of mechanical engineering and mechanics with the metallurgy and materials science department. Equipment is also available for vibration and other dynamic studies.

A master's degree program in design is available with the objectives of educating students in advanced design methods and encouraging the initiation and implementation of creative design projects. A wide range of interdisciplinary course offerings permits construction of a program in one or several of the following areas: mechanical systems, reliability engineering, probabilistic approaches to design, mechanism synthesis, digital and analog computer-aided design, ocean engineering, bio-mechanics, optimum design, and environmental design. In addition to formal course work the student will register for six hours of M.E. 460, design project, and submit an acceptable design project as the thesis.

For the master's degree a thesis will normally be required.

Any student who has not taken the mathematics courses required in the undergraduate mechanical engineering curriculum will be expected to make up for this deficiency in planning a graduate program. The student may then be required to present a larger number of credits than the minimum required for graduation.

Subject to proper approval, courses from other engineering curricula, such as mechanics, chemical engineering, and metallurgy and materials science, may be included in the major.

A student who plans to work for the doctorate should submit a general plan to the department chairman during the first year and arrange for the qualifying examinations.

420. Advanced Thermodynamics (3) every third semester
Critical review of thermodynamic systems. Criteria for equilibrium. Applications to electromagnetic systems. Statistical thermodynamics. Irreversible thermodynamics. Thermoelectric phenomena. Messrs. Macpherson and Owczarek.

421. Topics in Thermodynamics (3) fall
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.

424. Turbulent Flow (3) alternate years
Stability of laminar flow; transition to turbulence. Navier-Stokes equations with turbulence. Bounded turbulent shear flows; free shear flows; statistical description of turbulence. Prerequisite: M.E. 331. Mr. Rockwell.

426. Radiative and Conductive Heat Transfer (3) every third semester
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: M.E. 321 or Ch.E. 421. Mr. J. Chen.

427. (Ch.E. 427) Multiphase Heat Transfer (3) every third semester
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: M.E. 321 or Ch.E. 421. Mr. J. Chen.

428. Boundary Layers and Convective Heat Transfer (3) every third semester
Navier-Stokes and energy equations, laminar boundary layer theory, analysis of friction drag, heat 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: M.E. 331 or M.E. 321. Messrs. Levy, Owczarek and Rockwell.

431. Advanced Gas Dynamics (3) every third semester
Method of characteristics. Unsteady continuous flows. Unsteady flows with discontinuities. Shock tubes. Detonation waves. Two-dimensional and axisymmetric supersonic flows. Momentum and energy equation of compressible viscous fluids. Prerequisite: M.E. 322. Mr. Owczarek.

432. Topics in Gas Dynamics (3)
The equilibrium thermodynamic properties of a dissociating mixture of gases. Equilibrium flow of dissociating gases. Vibrational and chemical nonequilibrium. Criteria for thermodynamic equilibrium of gas flow. Chemical kinetics of gaseous reactions. Equations of flow of a reacting gas mixture. Nonequilibrium flows. Application to design of ram-jets and rocket nozzles and of re-entry vehicles. Prerequisite: M.E. 320, M.E. 322.

439. Fluid Mechanics of Turbo-machinery (3) every third semester
The Euler equation. One-dimensional analysis of turbomachinery. Performance characteristics. Limitations on performance imposed by real fluid effects. Cascade flow. Two- and three-dimensional flow. Surge and stall. Prerequisite: M.E. 322. Mr. Owczarek.

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. Messrs. Erdogan, Lucas and Sarubbi.

443. Analytical Methods in Engineering II (3) spring
Continuation of M.E. 442.

444. Experimental Stress Analysis in Design (3) alt. yrs.
Applications of experimental stress analysis to mechanical design problems. Mr. Wei.

446. Reliability Engineering (3) alternate years
Component catastrophic-failure models. System reliability analysis and design. Drift-failure, component tolerance and parameter variation. Physical failure models and parameter estimation. Prerequisite: Math. 231 or Math. 309. Mr. Benner.

448. (E.E. 448) Optimal Control and Design Theory (3) spring
Parameter optimization in design and optimal open-loop and feedback control via the extrema of unconstrained and constrained functions and functionals (calculus of variations). Matrix and state space formulation, Lagrange multipliers, Pontryagin maximum principle, Hamilton-Jacobi theory, matrix Ricatti equations, sensitivity analysis. Survey of observability and controllability, dynamic programming, and Kalman filter. Intended for engineers with a variety of backgrounds. Prerequisite: M.E. 340 or 343 or E.E. 212 or Ch.E. 286. Messrs. Benner, Brown and Johnson.

450. Special Topics (3)
An intensive study of some field of mechanical engineering not covered in more general courses.

451. Seminar (1-3)
Critical discussion of recent advances in mechanical engineering.

458. Modeling of Dynamic Systems (3) alternate years
Modeling of complex linear and nonlinear energetic dynamic engineering systems. Emphasis on subdivision into multiport elements and representation by the bond graph 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. Prerequisite: M.E. 342, or M.E. 343, or E.E. 212. Mr. Brown.

459. Advanced Systems Control (3) alternate years
Stochastic signals in estimation and optimal feedback control. Numerical techniques for nonlinear two-point boundary value problem. Stability and design criteria for nonlinear systems. Prerequisite: M.E. 448 (E.E. 448). Messrs. Brown and Johnson.

460. Design Project (1-6)
Selected design project in an area of student and faculty interest where the need for creative design work is recognized. Economic as well as physical and functional aspects are considered. Laboratory testing and data acquisition are carried out as needed to promote design development. Prototypes are constructed and tested, when practical.

Mechanics

Undergraduate Courses

1. Statics (3) fall-spring
Composition and resolution of forces; equivalent force systems; equilibrium of particles and rigid bodies; centroids and centers of gravity; analysis of simple structures; internal

forces in beams; friction; moments and products of inertia; method of virtual work. Prerequisites: Math. 22 and Phys. 11.

11. Mechanics of Materials (3) fall-spring
Strength and elasticity of materials; theory of stresses and strains; deflection of beams and shafts; torsion; buckling of struts. Prerequisites: Mech. 1; Math. 23, previously or concurrently.

13. Materials Testing Laboratory (1) fall-spring
Experiments to study the mechanical properties of engineering materials; correlation of the properties of different materials, of their behavior under different types of load application, and of mechanical properties of design criteria. Verification of certain assumptions used in Mech. 11. Prerequisite: Mech. 11, preferably concurrently.

102. Dynamics (3) fall-spring
Kinematics and kinetics of particles and rigid bodies in two and three dimensions; relative motion; work and energy; impulse and momentum. Prerequisites: Mech.1; Math. 23.

103. Principles of Mechanics (4) spring
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.

For Advanced Undergraduates and Graduates

203. Advanced Strength of Materials (3) fall-spring
Elementary consideration of stress and strain at a point. Stress-strain relations in two dimensions. Basic equations of motion. Classical theories of failures. Analysis of simple continuum systems with applications to materials behavior phenomena. Prerequisites: Mech. 11, Math. 205.

302. Advanced Dynamics (3) spring
Fundamental dynamical 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. Messrs. Beer and Sarubbi.

305. Advanced Mechanics of Materials (3) fall
Selected problems of stress and strain that are governed by ordinary differential equations such as combined bending and torsion of bars, curved bars, beams on elastic foundation. Membrane analogy. Principles of indeterminate analysis. Energy methods. Prerequisites: Mech. 203 or equivalent; Math. 205. Messrs. Erdogan and Hilton.

307. Mechanics of Continua (3) spring
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 the theories of perfectly elastic materials and also perfectly plastic materials. Prerequisites: Mech. 203 and 305. Messrs. Rivlin and Smith.

313. Fracture Mechanics (3) spring
Fracture behavior in solids, the Griffith theory and extensions to linear elastic fracture process models; stress analysis of cracks; generalization of fracture criteria; plasticity; subcritical crack growth, including environmental and thermal effects; fracture toughness testing; failure analysis and fracture control plans. Prerequisites: Mech. 11, Math. 205. Messrs. Roberts, Sih and Wei.

323. (C.E. 324) Fluid Mechanics of the Ocean & Atmosphere (3) fall
Hydrostatics of the ocean and atmosphere. Vertical stability. Fluid motion in a rotating coordinate system. Geostrophic flow; ocean currents; surface and internal waves. Prerequisite: M.E. 231 or C.E. 121. Mr. Macpherson.

326. Aerodynamics (3) spring
Application of fluid dynamics to external flows. Simple exact solutions in two dimensions. Kutta condition at a trailing edge. Thin aerofoil theory, steady and unsteady flow. Lifting line theory. Flow past slender bodies. Linearized compressible flow. Far field solutions, shock formation. Prerequisite: M.E. 231; Math. 208. Messrs. Blythe and Venkataraman.

350. Special Topics (3)
A study of some field of engineering mechanics not covered in the general courses. Prerequisite: consent of department chairman.

For Graduates

The graduate courses in mechanics are open in general to students who have been graduated from a curriculum in engineering mechanics, engineering mathematics, engineering physics, civil engineering, or mechanical engineering at a recognized institution.

A candidate for the M.S. degree 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. Any of these courses which have not been taken by the student as an undergraduate should be included in the graduate program. The student may then be required to present a larger number of credits than the minimum required for graduation. A thesis carrying three to six credit hours is required of all candidates for the M.S. degree.

Current departmental research activities of interest include programs as follows:

Continuum Mechanics. Formulation of field equations and constitutive equations in non-linear continuum mechanics. Problems in finite and linear elasticity theories. Mechanics of viscoelastic solids and fluids. Plasticity theory. Generalized continuum mechanics. Thermomechanical and electro-mechanical interactions. Stress birefringence. Wave propagation. Finite amplitude wave propagation.

Fracture Mechanics. Stress analysis of media containing inclusions or perforations, including visco-elastic, nonhomogeneous, and anisotropic materials. Analysis of crack growth under static, periodic, and random loadings and environmental effects. Optimizations of fracture control. Crack propagation theories for non-linear materials. Influence of cracks on the strength of structural members.

Stochastic Processes. Response of systems to stochastic inputs, including the effects of multi-dimensional fields and non-stationary processes. Prediction theory. Cumulative damage under random loads.

Thin Shell Analysis. Free vibration and dynamic response of elastic shells. Elastic-plastic deformations of shells upon cyclic thermal loadings. Applications of shell analysis to nuclear power plant components (pressure vessels, curved pipes), and to biological systems (eye, frog's eggs and other cells).

Fluid Mechanics. Finite amplitude waves in stratified gases and fluids. Shock propagation and problems related to the sonic "boom." Non-equilibrium and low density flows. Boundary layer separation and wake models. Flows of non-Newtonian fluids in flexible tubes, with application to hemorheology. Magneto-fluid mechanics. Wing theory. Three-dimensional flow in planar nozzles and in confined jets. Dynamics of unstable jets and jet interaction processes. Behavior of jets on acoustic fields. Switching dynamics in bistable amplifiers. Noise correlation studies in bounded jet flows.

Special departmental facilities of interest to the graduate student include the latest mechanical, electrodynamic and servocontrolled hydraulic testing machines.

402. Advanced Analytical Mechanics (3) alt. yrs.
Fundamental dynamical theorems and their applications to advanced problems; generalized coordinates; Lagrange's equations; fixed and moving constraints; non-holonomic systems; Hamilton's principle; Hamilton's canonical equations; contact transformations; Hamilton-Jacobi partial differential equation. Prerequisite: Mech. 302 or consent of department chairman. Messrs. Beer and Johnson.

405. Response of Systems to Random Loads (3) alt. yrs.
Stochastic processes; correlation functions and power spectra; response of mechanical systems to one-dimensional and multidimensional random load fields; probability theory for several random variables; statistical properties of the random vibrations of mechanical systems; applications to failure prediction. Prerequisite: consent of department chairman. Messrs. Beer and Sarubbi.

406. Advanced Vibrations (3) alternate years
General theory of eigenvalue problems for discrete and continuous dynamical systems; Sturm Liouville theory, variational techniques; transient and frequency response. Prerequisite: M.E. 242 or consent of department chairman. Messrs. Erdogan and Sarubbi.

407. Wave Propagation in Solids (3) alt. yrs.
Wave propagation in deformable elastic solids; problems in half-space and layered media; application of integral transformations. Mr. Erdogan.

409. Theory of Elasticity I (3) fall
Kinematics of deformation, analysis of stress, stress-strain relations, strain energy function. Reciprocal theorem. Methods for two-dimensional boundary value problems applied to anti-plane, torsion, bending and plane problems. Approximate and numerical methods of solution. Prerequisites: Math. 205; Mech. 305 or equivalent course in advanced mechanics of material. Messrs. Hartranft, Lucas and Sih.

410. Theory of Elasticity II (3) alt. yrs.
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 department chairman.

411. (Phys. 471) Continuum Mechanics (3) fall
An introduction will be given to the continuum theories of the mechanics of solids and fluids. This will include 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 will be given. Messrs. Rivlin and Smith.

412. Theory of Plasticity (3) spring
Mechanical behavior in the plastic range; foundations of the theory of plasticity; axisymmetric problems; limit analysis theorems; plane strain and slip line theory; applications to metal forming; introduction to plastic analysis of structures. Prerequisites: Math. 205; Mech. 305, or equivalent course in advanced mechanics of materials. Mr. Updike.

413. Fracture Mechanics (3) alternate years
Introduction to the Griffith-Irwin theory of static strength of bodies containing cracks; stress-intensity-factor methods; application to fatigue crack growth; complex variable methods of stress analysis of cracks for extension and bending of plates, for torsion and flexure of bars, and for thermal stress problems; viscoelastic, anisotropic, and non-homogeneous effects. Prerequisites: Mech. 203, Math. 208, or consent of department chairman. Messrs. Sih and Wei.

415. (C.E. 468) Stability of Elastic Structures (3) alt. yrs.
Basic concepts of instability of a structure; bifurcation, energy increment, snap-through, dynamic instability. Analytical and numerical methods of finding buckling loads of columns. Postbuckling deformations of cantilever column. Dynamic buckling with nonconservative forces. Effects of initial imperfections. Inelastic buckling. Buckling by torsion and flexure. Variational methods. Buckling of frames. Instability problems of thin plates and shells. Prerequisite: Math. 205. Mr. Kalnins.

416. Theory of Thin Shells alternate years
Derivation of the complete linear governing equations for a thin shell: differential geometry; analysis of strain; stress resultants and equilibrium; relations between stress resultants and strain; integral identities in shell theory; layered shells. Numerical and analytical methods of solution of shell equations. Governing equations and solutions for thin plates. Vibrations of plates and shells. Nonlinear theories of plates and shells. Prerequisites: Math. 205; Mech. 305, or equivalent course in advanced mechanics of materials. Mr. Kalnins.

417. Mixed Boundary Value Problems in Mechanics (3) alt. yrs.
General description of mixed boundary value problems in potential theory and solid mechanics. Solutions by dual series, dual integral equations and singular integral equations. Approximate and numerical methods. Mr. Erdogan.

418. Finite Element Method (3) alt. yrs.
The finite element method for continua is developed from relevant energy principles. Examples from elasticity, heat transfer, and fluid mechanics are used to illustrate alternative element choices and implementation. Applications to fracture mechanics and nonlinear phenomena are discussed. The course includes the development and use of computer programs to perform the implied calculations. Prerequisites: Mech. 305 or equivalent course, and knowledge of Fortran. Mr. Hilton.

421. Fluid Mechanics (3) fall
Kinematics of fluid flow. Lagrangian and Eulerian descriptions. Basic conservation laws. Review of thermodynamics. Constitutive relations. Vorticity, circulation. Irrotational flow. Bernoulli theorems. Vortex motion, velocity potential, stream function. Potential flow in two and three dimensions. Compressible flow; sound waves, simple waves; gas dynamic discontinuities. Mr. Salathe.

422. Fluid Mechanics (3) alternate years
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. Mr. Salathe.

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. Mr. Varley.

437. (Met. 437) Dislocations and Strengths in Crystals (3) alt. yrs.
For course description, see Met. 437. Messrs. Chou and Wei.

450. Special Problems (3)
An intensive study of some field of applied mechanics not covered in more general courses.

Metallurgy and Materials Science

Professors

George Powell Conard, Sc.D., *Chairman*
Joseph Francis Libsch, Sc.D., *Alcoa Professor and Vice President–Research*
Betzalel Avitzur, Ph.D. *Director, Institute for Metal Forming*
Sidney Roy Butler, Ph.D.
Ye Tsang Chou, Ph.D.
Walter Charles Hahn, Jr., Ph.D.
D. P. H. Hasselman, Ph.D.
Richard Warren Hertzberg, Ph.D.
Ralph Wayne Kraft, Ph.D., *New Jersey Zinc Professor*
George Krauss, Jr., Sc.D.
Alan Wiggins Pense, Ph.D.
Donald M. Smyth, Ph.D., *Director, Materials Research Center*
Richard Moore Spriggs, Ph.D., *Vice President–Administration*
Robert Daniel Stout, Ph.D., *Dean of the Graduate School*
Stephen Kenneth Tarby, Ph.D.
David Alden Thomas, Ph.D., *Associate Director, Materials Research Center*

Associate Professors

Joseph Irwin Goldstein, Ph.D.
John Dudley Wood, Ph.D.

Assistant Professor

Michael Richard Notis, Ph.D.

Progress in many fields of engineering depends upon discovery of new materials and a better understanding of the behavior of existing materials. Interest in new materials for solid-state devices, for application of nuclear energy and for space technology, as well as a better understanding of the behavior of materials in the design of structures, automobiles and aircraft, plant processing equipment, electrical machinery, etc., have increased the need for people trained in the science and technology of metals and other materials. The curriculum in metallurgy and materials science is designed to train graduates for research, development, operations, management and sales careers in industry or for graduate study in metallurgy and materials science.

Training 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 which broaden the student's outlook and enhance his or her professional development after graduation.

The objective of the program is to combine a fundamental understanding of the behavior of materials from the electronic, atomic, crystallographic, microstructural and macrostructural viewpoints with knowledge of the technology of materials preparation and processing. The student will thus receive a broad education with emphasis on the factors which govern the mechanical, physical, and chemical properties of materials to aid in the analysis, development, selection and use of materials for all types of industries. While some graduates go directly into metal producing companies, a large proportion serve as metallurgists or materials engineers in the chemical, electrical, transportation, communications, space and other metal and materials consumer industries. A number of students pursue graduate study for university teaching and research careers.

Recommended Sequence of Courses

Freshman Year (See page 52)

*Sophomore Year, First Semester (16-17 credit hours)**

Math 23	Analytical Geometry and Calculus III (4)
Phys 21, 22	Introductory Physics III and Lab (5)
Eco 1	Economics (4)
Met 63	Engineering Materials and Processes or
Met 91	Elements of Materials Science or
	GS Elective (3)
Met 10	Metallurgy Laboratory or
Mech 13	Materials Testing Laboratory
	either in fall or spring semester (0-1)

*Sophomore Year, Second Semester (15-17 credit hours)**

Math 205	Linear Methods or
Math 231	Probability and Statistics (3)
EE 160	Electrical Circuits and Apparatus or
Phys 31	Introduction to Quantum Mechanics (3-4)
Mech 1	Statics (3)
	GS Elective (3)
Met 63	Engineering Materials and Processes or
Met 91	Elements of Materials Science or
	GS elective (3)
Met 10	Metallurgy Laboratory or
Mech 13	Materials Testing Laboratory
	either in fall or spring semester (0-1)

*Met. 10 or Mech. 13 and Met. 63 or 91 are required for graduation and should normally be taken during the sophomore year.

Junior Year, First Semester (15-18 credit hours)

ChE 60	Unit Operations (3)
Mech 11	Mechanics of Materials (3)
Met 207	Electronic and Crystal Structure (3)
Met 210	Metallurgical Thermodynamics (3)
	GS Elective (3)
	Elective (0-3)*

*Please refer to description of normal program, page 52.

Junior Year, Second Semester (16-17 credit hours)

ME 166	Procedures for Mechanical Design or
Mech 102	Dynamics (2-3)
Met 101	Professional Development (1)
Met 208	Phase Diagrams and Transformations (3)
Met 218	Mechanical Behavior of Materials (3)
Met 304	Extractive Metallurgy I (4)
	Elective (3)

Summer

Met 100	Summer Employment

Senior Year, First Semester (18 credit hours)

Met 305	Extractive Metallurgy II (3)
Met 307	Structure and Behavior of Materials (3)
Met 313	Materials Fabrication (3)
	Engineering Science Elective (3)**
	Electives (6)

Senior Year, Second Semester (15-18 credit hours)

Met 278	Metallurgical Reports (3)
Met 358	Selection of Materials (3)
	Engineering Science Elective (3)**
Met	Approved Elective (3)
	GS Elective (3)
	Elective (0-3)*

*Please refer to description of normal program, page 52.
**Engineering science electives include, for example, Ch.E. 41, 52, 320, 321; Chem. 187, 196, 396; I.E. 205, 206, 212; E.E. 11, 20, 103; Mech. 102, 203, 313; Met. 312, 314, 333, 334.

In addition to the regular program, there are two options in the curriculum oriented to emphasize (1) industrial metallurgy, and (2) preparation for graduate research in materials.

Industrial Metallurgy Option

The industrial metallurgy option is designed to prepare students in a four-year program as plant metallurgists or materials engineers. To assist in this objective, students electing the option take two special courses, Met. 327 and 329, in place of an equivalent number of other specified courses. The emphasis in these courses is a team approach to the solution of actual plant problems. The course is conducted in cooperation with local industries. Three days per week are spent at

the plant of the cooperating industry on investigations of selected problems in plant operations. 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.

Junior Year

Same as regular program.

Summer

Met 100	Industrial Employment

Senior Year, First Semester (17-20 credit hours)

Met 327	Industrial Metallurgy (4)
Met 329	Industrial Metallurgy (4)
Met 305	Extractive Metallurgy II (3)
Met 307	Structure and Behavior of Materials (3)
Met 313	Materials Fabrication (3)
	Elective (0-3)*

Senior Year, Second Semester (17 credit hours)

Met 338	Metallurgy Colloquium (2)
Met 358	Selection of Materials (3)
Met	Approved Elective (3)
	GS Elective (3)
	Engineering Science Elective (6)**

*Please refer to description of normal program, page 52.
**Engineering science electives include, for example, Ch.E. 41, 52, 320, 321; Chem. 187, 196, 396; I.E. 205, 206, 212; E.E. 11, 20, 103; Mech. 102, 203, 313; Met. 312, 314, 333, 334.

Research Option

For those students who may be interested in teaching, research, or development, and intend to pursue graduate work, a research option is offered. In this option, students are required to take Met. 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.

Junior Year, Second Semester (18-19 credit hours)

Same as regular program with the following addition:

Met 240	Research Techniques (2)

Summer

Met 100	Industrial Employment or Undergraduate Summer Research

Senior Year, First Semester (15-18 credit hours)

Met 291	Experimental Metallurgy (3)
Met 305	Extractive Metallurgy II (3)
Met 307	Structure and Behavior of Materials (3)
Met 313	Materials Fabrication (3)
	Elective (3-6)*

Senior Year, Second Semester (17 credit hours)

Met 338	Metallurgy Colloquium (2)
Met 358	Selection of Materials (3)
Met	Approved Elective (3)
	G.S. Elective (3)
	Engineering Science Elective (6)**

Please refer to description of normal program, page 52.
**Engineering science electives include, for example, Ch.E. 41, 52, 320, 321; Chem. 187, 196, 396; I.E. 205, 206, 212; E.E. 11, 20, 103; Mech. 102, 203, 313; Met. 312, 314, 333, 334.

Undergraduate Courses

10. Metallurgy Laboratory (1) fall-spring
Application of equipment for laboratory study of structure and properties of metals. Prerequisite: Met. 63 or 91 previously or concurrently.

63. Engineering Materials and Processes (3) fall-spring
Engineering materials and their properties. Methods and effect of fabrication and treatment. Application and use of materials in engineering. Primarily metals, but including plastics, ceramics, and other engineering materials. Prerequisites: Chem. 21; Phys. 11 or 16.

91. Elements of Materials Science (3) fall-spring
Introductory study of the relationship between structure (on the atomic, crystallographic or molecular, micro and macro scales) and physical and mechanical properties of metallic, ceramic, and polymeric materials. Influence of processing variables on structure and properties. Lectures and recitation. Prerequisites: Chem. 21; Phys. 21 or 16 previously or concurrently.

100. Industrial Employment
In the summer following the junior year students in the curriculum of metallurgy and materials science are required to secure at least eight weeks of experience in industrial plants or research organizations.

101. Professional Development (1) spring
Meetings with the department staff for the purpose of developing a professional outlook of the engineering student. Required reading, oral reports and term papers. Prerequisite: junior standing. Consent of department chairman.

204. Nonmetallic Materials of Construction (3) spring
The principles and technology of nonmetallic materials of present and future use in civil engineering and architecture. Mechanical, environmental, and physical properties of the classes of materials are related to their compositions, internal structures, and methods of manufacture. Materials include concrete, asphalt, and fiberglass-reinforced plastics. Applications include appearance and durability, thermal expansion and sealants, and acoustics. Lectures and some laboratories. Prerequisites: Mech. 11 or consent of department chairman. Chemistry desirable but not required. Mr. Thomas.

For Advanced Undergraduates and Graduates

207. Electronic and Crystal Structure (3) fall
Atomic theory, chemical bonding, lattice concepts, and theory of X-rays. Nature of crystalline phases, imperfections, and atom movements. Electron theories of solids. Lectures and laboratory. Prerequisites: Met. 10 or Mech. 13, previously or concurrently, and Phys. 21.

208. Phase Diagrams and Transformations (3) spring
Thermodynamic basis for equilibrium. The phase rule. Equilibrium phase diagrams and non-equilibrium considerations. Solidification and solid state phase changes. Rationalizations of microstructures. Recovery, recrystallization, and grain growth. Lectures and laboratory. Prerequisites: Met. 207, Met. 210.

210. Metallurgical Thermodynamics (3) fall
The applications of thermodynamic relations to metallurgical processes with emphasis on solving specific problems for processes such as the open hearth for steel, heat treating atmospheres, alloy equilibrium diagrams, and others. Lectures and problem sections. Prerequisite: Math. 23. Mr. Hahn.

211. Metallic Materials for Structures (3) fall
The structure and behavior of structural steels, aluminum and other alloys, with emphasis on materials used in large-scale engineering structures such as bridges, buildings, and pressure vessels. Fracture mechanics concepts, the physical metallurgy of alloys involved, and fabrication of structures, especially welding. The relationship between materials, fracture control and fabrication. Not open to majors in metallurgy. Lectures and laboratory. Prerequisite: Met. 63 or equivalent and senior standing. Messrs. Hertzberg and Pense.

218. Mechanical Behavior of Materials (3) spring
Deformation and fracture behavior of materials. Elastic and plastic behavior, with emphasis on crystallographic consideration. Strengthening mechanisms in solids. Static and time dependent fracture from metallurgical and continuum viewpoints. Lectures and laboratory. Prerequisites: Mech. 11, Met. 207, Met. 63 or Met. 91. Mr. Hertzberg.

240. Research Techniques (2-3) spring
Study, analysis, and application of experimental techniques in metallurgical and materials research. Analysis of experimental data and methods of presentation. Design of experimental programs. Recitations and laboratory. Restricted to small numbers of students by the department.

278. Metallurgical Reports (3) spring
An opportunity for the advanced student to develop familiarity with current metallurgical literature and to present oral reports and a comprehensive written survey. Prerequisite: senior standing.

291. Experimental Metallurgy (3)
Application of research techniques to a project in metallurgy or materials science selected in consultation with the senior staff. Prerequisite: Met. 240.

300. Apprentice Teaching in Metallurgy (1-3)

304. Extractive Metallurgy I (4) spring
A unit process study of extractive metallurgy techniques. Includes chemical principles, thermochemistry, and kinetics; also phases in pyrometallurgical systems, combustion of fuels, and refractories. The preparation, treatment, and handling of materials for primary crude metal production. Lectures plus laboratory. Prerequisite: Ch.E. 60, Met. 210. Mr. Hahn.

305. Extractive Metallurgy II (3) fall
Continuation of Met. 304. A detailed engineering analysis of important metallurgical processes. A study of the thermodynamic and kinetic aspects of these processes. Development of mathematical models of processes by computer programming. Lectures, laboratory, and plant trips. A three-day inspection trip is required. Prerequisite: Met. 304. Mr. Tarby.

306. Optimization of Metallurgical Processes (3)
Numerical methods will be used to investigate metallurgical reactions and processes. Problems relating to the optimization of processes in the ferrous and nonferrous fields will be studied. Lectures and computer-oriented problems. Prerequisites: A knowledge of computer programming and consent of department chairman. Mr. Tarby.

307. Structure and Behavior of Materials (3) fall
Correlation of structure and properties of engineering materials. Design of thermal, chemical, and mechanical treatments to develop optimum properties in metals, ceramics, and polymers. Lectures and laboratory. Prerequisites: Met. 218, Met. 208. Mr. Pense.

312. (Ch.E. 312) Fundamentals of Corrosion (3)
For course description, see Ch.E. 312.

313. Materials Fabrication (3) fall
Basic concepts of stress, strain, and stress-strain behavior under load. Analysis and description of metal forming, metal cutting, casting, joining, and powder metallurgy. Lectures and laboratory. Prerequisite: Met. 63 or Met. 91, or equivalent. Mr. Avitzur.

314. Advanced Metal Forming (3)
Extension of Met. 313. 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: Met. 313. Mr. Avitzur.

315. Introduction to Physical Ceramics (3)
Methods of fabrication, physical properties, and applications of ceramic materials, including oxides, carbides, nitrides, borides and silicides. Correlation of atomic bonding, microstructure and physical behavior in service environments. Special topics, including electronic ceramics, nuclear ceramics, refractories, cutting tools and abrasives. Prerequisites: Chem.

21 and Phys. 11 or consent of department chairman. Mr. Hasselman.

316. Physical Properties of Materials (3)
Consideration of observed electrical, magnetic, thermal, and optical properties of crystalline materials with emphasis on their relationship to electron configuration and crystal structure. Lectures and laboratory. Prerequisite: Met. 207 or Phys. 31, or consent of department chairman. Messrs. Notis, Conard or Butler.

317. Imperfections in Crystals (3)
The types of imperfections in crystals and their effects on the behavior of crytalline materials with particular emphasis on dislocations. Prerequisite: Met. 63 or 91, or equivalent. Mr. Chou.

319. Current Topics in Materials Science (3)
Selected topics of current interest in the field of materials science but not covered in the regular courses. May be repeated for credit with consent of the department chairman. Prerequisites: Met. 210 and Met. 218.

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, and diffusion. Prerequisite: Math. 231 or Math. 205. Mr. Chou.

322. Materials Technology in the Energy Crisis (3) spring
Impact of materials on energy including nuclear and solar energy and solar cells, coal gasification, MHD power generation and superconductors. Energy resources, conversion, and consumption. Materials limitations on development of energy alternatives in transportation, power and primary metals industries. Industry and government lecturers will participate. Prerequisite: Met. 63, Met. 91 or consent of department chairman. Mr. Notis.

327. Industrial Metallurgy (4) fall
This course is 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 at the plant of the Bethlehem Steel Corporation for research in plant operations. Application by a graduate student for admission to this course must be made prior to March 1 of the previous semester. Mr. Tarby.

329. Industrial Metallurgy (4)
To be taken concurrently with Met. 327. Course material is the same as Met. 327.

333. (Geol. 337) X-ray Methods (3) fall
Fundamentals and experimental methods of X-ray techniques. Application to various materials problems including diffraction, radiography, fluorescent analysis. Lectures and laboratory work. Prerequisite: Phys. 21, Met. 91 or equivalent. Mr. Kraft.

334. (Geol. 338) Electron Metallography (3) spring
Fundamentals and experimental methods of one or more of the electron beam techniques. Specific topics include electron optics, electron beam interactions with solids, electron diffraction, chemical microanalysis and transmission and scanning electron microscopy. Applications to the study of the structure of material will be given. Special laboratories are given in cooperation with other departments as required. May be repeated for credit if new material is presented. Prerequisite: consent of department chairman. Messrs. Krauss and Goldstein.

338. Metallurgical Colloquium (2) spring
An opportunity for the student to develop an acquaintance with the current metallurgical literature, the ability to interpret such literature clearly, and skill in presenting oral engineering reports. Prerequisite: consent of department chairman.

343. (Ch.E. 393, Chem. 393) Physical Polymer Science (3)
For course description, see Ch.E. 393.

358. Selection of Materials (3) spring
Problems relating to design and service requirements of material components. Selection of materials-fabrication, and finishing processes. Failure analysis. Discussion of specific examples involving materials. Lectures, problems. Prerequisites: Met. 307 and Met. 313, or consent of department chairman. Mr. Wood.

361. Physics of Materials (3)
Principles of quantum mechanics and statistical thermodynamics. Intended to provide a basic understanding of the principles underlying the study of structure and properties of materials. Prerequisites: Met. 91 or equivalent, Math. 205.

396. (Chem. 396) Solid State Chemistry (3)
Chemistry of ionic and electronic defects in solids and their influence on chemical and physical properties. Intrinsic and impurity-controlled defects, non-stoichiometric compounds, ordering of defects at surfaces and interfaces. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, photoconductivity, rectifying junctions, chemisorption, and catalysis. Prerequisite: Chem. 90 or Met. 210 or equivalent of either.

For Graduates

The department offers three degrees: a master of science and a doctor of philosophy in metallurgy and materials science, and a master's in materials. This latter degree is part of a special five-year program which is described on page 153.

A diversity of programs and curricula are available to a person interested in graduate study in the area of materials. The department of metallurgy and materials science generally is the department from which a degree is earned. 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 of metallurgy and materials science has

both 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 and metallurgy. At the same time, those advanced students who desire it are usually provided the opportunity to gain experience in teaching 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 metallurgy or materials science 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 advisor. Under the advisor's direction, the student plans a course of study to satisfy individual needs and interests. The department has established specific recommended programs for the master of science or doctor of philosophy emphasizing the following areas: chemical metallurgy, materials engineering, materials science, mechanical metallurgy, physical ceramics, and physical metallurgy. These programs are not rigid. The program in chemical metallurgy offers a cooperative "Chem.-Met." program with the chemical engineering department. Through cooperation with the mechanical engineering department similiar arrangements have been made to extend the materials engineering program to include an option in materials design. The emphasis of the mechanical metallurgy program is on the analysis of metal forming operations. Many students, however, have specialized in other areas of mechanical metallurgy, such as deformation and fracture analysis, either through combined programs in physical and mechanical metallurgy or through cooperation with the departments of mechanics or mechanical engineering and the Materials Research Center. The physical ceramics program emphasizes unique processing techniques as well as the study of the physical behavior of various ceramic systems.

Graduate school requirements are explained in one of the two gold sections of this catalog. In this department, a candidate for the degree of master of science must complete a thesis. This normally represents six of the thirty semester hours required for this degree.

A candidate for the Ph.D. prepares a preliminary program of courses and research providing for specialization in some phase of metallurgy, materials science, or materials engineering (largely through research) in consultation with the advisor. Prior to formal establishment of the doctoral program by the special committee and its approval by the Graduate School, the student must pass a qualifying examination which must be taken early in the first year of doctoral work. The department does not require a foreign language; however, 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 for students in metallurgy and materials science. 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, traineeships, and assistantships are available. This type of aid generally provides for tuition, an allowance for experimental supplies, and a stipend to the student. To date, the Internal Revenue Service has allowed this stipend to be tax-free. For details of graduate scholarships, fellowships and assistantships, please refer to the gold Graduate School section.

A number of graduate students in metallurgy and materials science do their research in the Materials Research Center. The list of research activities notes the many areas of interest and the asterisks indicate research of an interdisciplinary nature.

Chemical Metallurgy

Kinetics of metallurgical reactions
Mathematical modeling of metallurgical processes
Thermodynamics of metallic solutions
Thermodynamics and phase equilibria

Materials Science

Characterization of metal oxide films*
Crystal growth*
Deformation and recrystallization texture studies
Deformation of bicrystals
Dislocation studies
Eutectic research including solidification, microstructure, and property studies*
Magnetic materials
Meteorites and lunar materials
Photoelectric studies of insulators
Preparation and properties of materials for solid state devices*
Processing of metal insulator semi-conductor structures and their evaluation and application to integrated circuits*
Quantitative metallography
Solidification of tool steels
Structure and behavior of solid state materials*
Structure and properties of sputtered, evaporated, and plated thin films*

Mechanical Metallurgy

Cladding and forming of composite materials
Correlation of microstructure with mechanical behavior of low-alloy high-strength steels, especially fatigue, creep and brittle fracture
Deep drawing, impact extrusion and ironing
Deformation and fracture of eutectic composites
Ductile fracture
Effect of holes, inclusions and pressure on the tensile properties
Electron fractography*
Environmental crack kinetics*
Fatigue crack propagation studies of metals and polymers*
Flow through converging conical dies
Forming of polymers*
Friction measurement
Hydrostatic extrusion
Influence of welding on fatigue characteristics of weldments*
Mechanical behavior of anisotropic materials*
Pressure-induced ductility

Theoretical analysis of metal forming methods and correlation with metallurgical parameters
Toughness of weld metal
Weldability of steels

Physical Ceramics

Diffusion in multi-component ceramic systems*
Fracture toughness and crack propagation behavior in refractory materials*
Kinetics of phase transformations in ceramics*
Mechanism of wear and abrasion in ultra-hard materials*
Microstructure aspects of the strength, elasticity, and creep behavior of high-purity alumino-silicate ceramics*
Polymer reinforced ceramics*
Pressure-sintering kinetics of ceramics*
Static and cyclic fatigue of ceramics*
Strengthening mechanisms in impregnated porous brittle materials*
Strengthening mechanisms of glasses and ceramics by surface compression*
Synthesis and characterization of polycrystalline diamond compacts*
Synthesis characterization and densification kinetics of ultra-fine ceramic powders*
Theoretical analysis of deformation, fracture and flow characteristics of brittle materials*
Thermal stress fracture and spalling mechanisms in brittle ceramics*
Thermoviscoelastic behavior of ceramics and glasses*

Physical Metallurgy

Creep-rupture and aging, brittle fracture characteristics, and fatigue properties of low-alloy, high-strength steels*
Diffusion controlled growth
Kinetics of solid state reactions*
Metallurgical factors affecting machining*
Physical metallurgy of aluminum alloys
Physical metallurgy of sintered carbides*
Recrystallization
Strengthening mechanisms
Structure and morphology of martensite
Tempering
Ternary diffusion
Transmission electron microscopy of crystal defects
X-ray measurement of residual stresses*

Polymers

Environmental effects on polymers to protect concrete against corrosion*
Fatigue crack propagation in engineering plastics*
Fracture surfaces of crystalline polymers*
Mechanical behavior of interpenetrating networks*
Mechanical behavior of polyvinyl chloride*
Mechanisms of sintering of polymers*
Reinforcement of silicon rubber by silica fillers*
Second-order transitions in cellulose triesters*

401. Thesis (1-6)
Investigation of some problem in the area of mechanical, chemical, and physical metallurgy or materials science. The study must be embodied in a written report. Prerequisite: undergraduate courses in the field of investigation. May be repeated for credit.

404. Materials in Modern Technology (3)
Detailed study of special processing techniques for, or chemical, mechanical, and physical behavior of, one or more of the materials in modern technologies, such as the cryogenic, nuclear, or aerospace fields. This course may be repeated for credit beyond three hours if new material is covered. Prerequisite: consent of department chairman.

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 natures of the freezing interface, segregation, constitutional super-cooling, dendritic growth, crystallographic effects, the origin of defects, crystal growing. Zone processes. Prerequisite: consent of department chairman. Mr. Kraft.

407. Theory of Alloy Phases (3)
Consideration of the application of the principles of thermodynamics, physics, and crystallography to the explanation and prediction of structure, physical properties and behavior of crystalline materials. Prerequisite: Met. 208. Desirable preparation: Phys. 363. Mr. Conard.

408. Transformations (3) fall
A description of phase equilibria and phase transformations with emphasis on the solid state. Phase diagrams and their thermodynamic basis. Physical and kinetic aspects of various types of phase transformations. Prerequisites: Met. 208, Met. 210. Mr. Krauss.

409. Recent Developments in the Theory of Materials (3)
Current topics and theoretical developments in materials. This course may be repeated for credit if new material is covered. Prerequisite: consent of department chairman.

410. Physical Chemistry of Metals (3)
Discussion of the thermodynamic properties of solid and liquid metals and alloy systems. Treatment of solution laws, methods of determining thermodynamic properties by experimentation and computation, changing standard states, and interaction parameters developed for liquid ferrous alloys. Prerequisite: Met. 210 or equivalent. Mr. Tarby.

411. Modern Joining Methods (3) alternate years
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. Prerequisites: Met. 208 and 218. Mr. Pense.

412. Electrical and Magnetic Properties of Materials (3)
The study of semiconducting, dielectric, magnetic and similar materials and their properties. Brief discussion of band theory, conduction and emission mechanisms and related topics. The relation between structure (including imperfections) and physical properties. Prerequisites: Met. 316 or Phys. 363, Chem. 196; or consent of department chairman. Mr. Butler.

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. Mr. Avitzur.

414. Physical Chemistry of Metallurgical Reactions (3)
Development of quadratic formalism for representation of the thermodynamic properties of binary and ternary metallic solutions. A study of the thermodynamic and kinetic aspects of process metallurgy reactions. Emphasis on the kinetic behavior of important slag-metal reactions. Prerequisite: Met. 410. Mr. Tarby.

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: Met. 218 or consent of department chairman. Mr. Hasselman.

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 non-metals. Prerequisite: Math. 23 and Chem. 196 or the equivalent. Messrs. Goldstein or Hahn.

418. Deformation and Fracture (3)
Slip and twinning in metals. Theories of deformation texture formation. Evaluation of atomistic, microstructural, and continuum fracture theories and their interrelation. Consideration of ductile and brittle fracture, fatigue, creep, and failure of composite materials. Utilization of electron fractography. Prerequisite: Met. 218 or equivalent. Mr. Hertzberg.

419. Alloy Steels (3) alternate years
Structures and transformations in iron and iron based alloys. Design and heat treatment of alloys for strength, toughness, creep, and corrosion resistance. Prerequisite: Met. 307. Mr. Pense.

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: Met. 208, Met. 218, Met. 315. Prerequisite: consent of department chairman.

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. Prerequisites: Math. 205 or 221, or Met. 320; Met. 317, or consent of department chairman. Messrs. Chou and Wei.

443. (Chem. 443) Solid State Chemistry (3)
For course description, see Chem. 443.

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 science knowledge for improved design. Solution and discussion of industrial problems, and outline of experimental approach. Prerequisite: consent of department chairman. Mr. Wood.

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 chairman.

Military Science

Professor

Colonel Charles T. Hamner, M.A., *Chairman*

Associate Professor

Major Donald H. Kunkel, M.Ed.

Assistant Professors

Captain Jerry R. Fry, B.S.
Captain Harold R. Manns, M.B.A.
Captain Richard M. Walsh, M.A.

Instructors

SGM Joseph Kress
MSG Robert Dunn

The general objective of the course of instruction is to produce junior officers who by education, training, and attitude are suitable for continued development as officers in the United States Army. The course develops in the student the characteristics of self-discipline, integrity, and responsibility. The student's ability to evaluate situations, make decisions, work with people, and lead effectively are developed. Additionally the student gains an appreciation of the role of a participating citizen in matters dealing with national defense. Lehigh has had a Reserve Officer Training Corps program since September, 1919. Currently, Army ROTC offers a four-year program and a two-year program through the military science department. The four-year program consists of a two-year Basic Course and a two-year Advanced Course, both of which are elective. Only students who have demonstrated a potential for becoming effective officers are approved for enrollment in the Advanced Course. The two-year program consists of a six-week basic summer camp and the two-year Advanced Course.

Basic Course. The Basic Course, normally taken in the freshman and sophomore years, provides training in basic military subjects, military history, weapons, equipment and leadership techniques. To enroll in the Basic Course, an applicant must be: (1) a citizen of the United States; (2) between 14 and 23 years old; (3) regularly enrolled as a student.

Two-Year Program. Students desiring to enroll in ROTC at any time after their sophomore year may apply for this program. Applicants must successfully complete a six-week basic 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.

Advanced Course. The Advanced Course is normally taken in the junior and senior years. The instruction includes military tactics, logistics, administration, communications, military law, teaching methods, leadership techniques and the exercise of command. Students in this course receive $100 per month subsistence pay during the school year. A six-week Advanced Course summer training camp is normally held between the junior and senior year. Pay for this camp is at the rate of $317.10 per month, plus travel expenses. The summer camp experience, in coordination with respective engineering curricula, may be used to fulfill the requirements of the engineering courses Ch.E. 100, C.E. 100, E.E. 100, I.E. 100, M.E. 100, and Met. 100, "Industrial Employment." To enroll in the Advanced Course, an applicant must: (1) complete either the Basic Course or the six-week basic summer camp; (2) be accepted for enrollment by the University and the department of military science.

Uniforms and equipment. All uniforms, textbooks and equipment needed by the student for military science courses are supplied by the department. Students will be charged for those items not returned at the appropriate turn-in date.

ROTC Scholarship Program. The ROTC scholarship program is designed to offer financial assistance to outstanding young men and women entering the four-year ROTC program who are interested in an Army career. Each scholarship provides free tuition, textbooks, and laboratory fees, in addition to pay of $100 per month for the period that the scholarship is in effect. Four-year scholarships are open to all students entering ROTC as freshmen. Applications must be made to Headquarters, First ROTC Region, Fort Bragg, N.C. 28307, during the junior or senior year of high school. This may be done as early as the spring semester of the junior year, but not later than December 31 of the senior year. Three-, two-, and one-year scholarships are available to outstanding cadets who are currently enrolled in the four-year ROTC program and are completing either their freshman, sophomore, or junior years of college.

Distinguished Military Graduate (DMG) Program. This is a competitive program which permits outstanding ROTC students to apply for a Regular Army commission immediately upon graduation. At the end of the junior year and upon completion of the Advanced summer camp, approximately one-third of each junior ROTC class may be designated as Distinguished Military Students (DMS). A student who maintains the same high standards throughout the senior year may qualify for designation as a Distinguished Military Graduate (DMG) and be offered a Regular Army commission upon graduation.

Flight Training Programs. For those students interested and qualified, a Flight Training Program may be offered. Flight training is an extracurricular activity conducted by an approved Federal Aviation Administration flying school near the university. The instruction consists of thirty-five hours of ground training and more than thirty-six hours of flight instruction in single-engine, fixed-wing aircraft. Students who take flight training must agree to participate, if selected, in the Army Aviation Program upon entering active service.

Transfers. Qualified students transferring from another institution may enter the ROTC program at the appropriate advanced level and year, providing the individuals have received the necessary credits, the recommendation of their former professor of military science, and the approval of Lehigh University.

Obligation after graduation. Usually upon graduation a student will receive a reserve commission as a second lieutenant and will be required to serve on active duty for two years, and then four years in a reserve status. Depending on Army requirements, a three- to six-month active duty for training with an eight-year reserve commitment is offered. Recipients of a Regular Army commission must serve at least three years on active duty. Scholarship students must agree to accept a Regular Army commission if offered and also serve four years on active duty. Graduates accepted for the Army Aviation Program must serve at least three years on active duty after

completing the Army Aviation School at Fort Rucker, Alabama.

Graduate Studies. Under normal circumstances ROTC graduates may delay their active service to pursue a full-time course of instruction leading to an advanced degree. This delay status does not lengthen the active service obligation unless the degree is obtained at government expense.

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 Physical Sciences, six credits of advanced ROTC work will be included within the normal program of each student, irrespective of his or her curriculum. For curricula which include more than six hours of personal electives in their junior and senior years, inclusion of more than six hours of ROTC credit within normal programs can only be effected with the approval of academic advisors. The two credits allotted for apprentice teaching will be in addition to the six hours of electives aforementioned. All military science credits are credited toward the student's over-all cumulative academic average.

Courses in Military Science

13. Basic Military Science (1) fall
This introductory course examines the purpose, history and organization of ROTC, the Army, the integration of small units into larger teams, the missions and function of Army units in relation to the roles of the Department of Defense and the other armed services, and the U.S. objectives of national security and defense. The course consists of one recitation period and two hours of leadership laboratory per week.

14. Basic Military Science (1) spring
This course examines an introduction to tactics, basic use of a map and compass, and instruction in marksmanship techniques. The course consists of one recitation period and two hours of leadership laboratory per week.

21. Basic Military Science (2) fall
This course presents map and aerial photography, to include use of the compass, small unit military tactics and operations, the systems, principles and techniques of military communications, and the organization and functions of basic military teams. The course consists of two recitation periods and two hours of leadership laboratory per week.

22. Basic Military Science (2) spring
This course is a study of the application of the principles of war observed in American military history. Historical engagements of U.S. Armed Forces are examined at the tactical level in order to foster an appreciation of tactical considerations, and to develop military planning ability among the students. The course consists of two recitation periods and two hours of leadership laboratory per week.

Advanced Course

105. Advanced Military Science (1) fall
This course examines the roles, missions and job opportunities of the various branches of the Army, the principles of military instruction, the techniques used in planning, presenting and evaluating instruction, and an overview of problems in underdeveloped countries and the role of the Army in their aid. This course consists of two recitation periods and two hours of leadership laboratory per week.

106. Advanced Military Science (2) spring
This course examines the leader's role in directing and coordinating small tactical units in the execution of offensive and defensive operations, and the psychological, physiological, and sociological factors which affect human behavior and leadership and management problems common to small units. The course consists of three recitation periods and two hours of leadership laboratory per week.

Advanced ROTC Summer Camp

This is a six-week training program conducted at an active Army post. Prerequisites are completion of the basic military science courses or their equivalent and Military Science 105 and 106. Under special circumstances and upon approval of the department chairman, this camp may be delayed until after graduation or completion of the Advanced Course. The summer camp experience, in coordination with respective engineering curricula, may be used to fulfill the "industrial employment" requirements of the engineering courses Ch.E. 100, C.E. 100, E.E. 100, I.E. 100, M.E. 100, and Met. 100.

107. Advanced Military Science (2) fall
This course is a study of military combat operations and the organization and roles of the various components of the military team, the coordination and planning necessary between the elements of the team, and the basic concepts of military intelligence, staff organization and functions, and logistics. The course consists of three recitation periods and two hours of leadership laboratory per week.

108. Advanced Military Science (1) spring
This course examines selected leadership and management problems involved in unit administration and military justice, the position of the United States in the contemporary world and the military implications of world change, and the obligations and responsibilities of an officer entering on active duty. This course consists of two recitation periods and two hours of leadership laboratory per week.

300. Apprentice Teaching in Military Science (2) fall-spring
Enrollment limited to selected MS IV students approved by the department chairman.

Leadership Laboratory

Leadership Laboratory is conducted for all courses at the same time. The Corps of Cadets is organized as a tactical unit and must plan, organize and conduct its own unit training program during the laboratory period. Cadets assume posi-

tions in the organization commensurate with their knowledge, experience and demonstrated performance. Each semester cadets move up the chain of command to positions of greater responsibility. During leadership laboratory cadets practice the technical skills learned in the classroom and develop their leadership skills through performance. Cadets learn the basic fundamentals of leadership, techniques of the exercise of command, development of command voice, the school of the soldier with and without arms, the conduct of ceremonies, the duties and responsibilities of junior leaders, the conduct of tactical operations, the functioning of a staff and the development and coordination of a unit training program.

Modern Foreign Languages and Literatures

Professors

Anna Pirscenok Herz, Ph.D., *Chairman*
Victor Manuel Valenzuela, Ph.D.
John Andrews Van Eerde, Ph.D.

Associate Professors

Arthur Parcel Gardner, Ph.D.
Anje C. van der Naald, Ph.D.
D. Alexander Waldenrath, Ph.D.

Assistant Professors

Allen E. Hye, Ph.D.
Safeta S. Juka, Dr. d'Univ.
Linda S. Lefkowitz, Ph.D.

Instructors

Duncan B. Gardiner, M.A.
Marian Masiuk, M.A.

The department of modern foreign languages and literatures offers separate major programs in French, German and Spanish aiming to show the development of the culture and civilization of the French, German and Spanish-speaking countries of Europe and Latin America. Required language and literature courses constitute a core around which the student can build a program of studies providing a broad and sound understanding of foreign cultures as part of the culture of the western world.

Each candidate is assigned a departmental advisor to correlate and integrate supplementary reading and study to meet special objectives.

All foreign language candidates are urged to participate in Lehigh University summer language programs abroad. Candidates in German are urged to participate in the Lehigh University spring semester in Germany. "Junior year abroad" programs and study travel in foreign countries are recommended.

The minimum requirement for the major is twenty-four credit hours. The candidate for the major is expected to gain a knowledge of literature and an adequate command of the language.

Specific courses other than those listed should include collateral work in ancient and modern European history, fine arts, music, and the languages and literatures of other peoples, i.e., English, French, German, Greek, Italian, Roman, Russian and Spanish.

The sequence of courses offered in any of the modern foreign languages is of particular relevance as preparation for careers in teaching and foreign service.

An interdisciplinary major combining a specialized field with a program of Russian language and literature studies is encouraged.

Modern Foreign Languages

301. General Linguistics (3) fall
Historical and descriptive linguistics: emphasis on articulatory phonetics, morphology, and structural grammatical analysis, especially as applied to pedagogy. Conducted in English. Mr. Gardiner.

302. The Teaching of a Foreign Language (3) spring
Conducted in English.

409. Theory of Literary Criticism (3) fall
The theory and practice of literary criticism for students of foreign literatures. Conducted in English.

French

Required Preliminary Courses

Fr 3	Elementary French (5)
Fr 4	Intermediate French (5)
Fr 13, 14	Advanced French (7)

Required Major Courses

Twenty-four hours to be chosen from courses above French 14.

Undergraduate Courses

3. Elementary French (5) fall
Basic conversational French illustrating essential grammatical principles, reading of simple texts and writing; some laboratory.

4. Intermediate French (5) spring
A continuation of French 3. Prerequisite: French 3, or Achievement Test score before entrance, or consent of chairman of department.

13. Advanced French (4) fall
A review of grammar but an emphasis on speaking and writing on topics affording an opportunity to master the current idiom through the use of materials of contemporary interest. Prerequisite: Fr. 4, or Achievement Test score before entrance, or consent of chairman of department.

14. Advanced French (3) spring
Emphasis on readings and discussion. Prerequisite: Fr. 13, or Achievement Test score before entrance, or consent of chairman of department.

43. French Oral and Written Composition (3) fall
For students who desire an opportunity for intensive practice in the oral and written use of French. Prerequisites: Fr. 14, or consent of department chairman, or Achievement Test score of 600. Ms. Masiuk.

44. French Oral and Written Composition (3) spring
Designed to aid students who have already satisfied the language requirement in French to develop an advanced degree of skill in speaking and writing the language. Ms. Masiuk.

46. Practical and Business French (3)
Selected readings on such current topics as public relations, the origin and role of banks, the industrial society, strikes, the Common Market. Practice in writing French for business. Conducted in French. Prerequisite: Fr. 13, or consent of department chairman. Ms. Juka.

51. A Survey of French Literature (3) PU fall
Training in the ability to read and understand representative works from the Middle Ages to the nineteenth century. Outside reading. Conducted in French. Prerequisites: Fr. 14 or consent of department chairman. Mr. Van Eerde.

52. A Survey of French Literature (3) PU
Reading and discussion of representative works of the nineteenth and twentieth centuries. Outside reading. Conducted in French. Prerequisites: Fr. 51 or consent of department chairman. Mr. Van Eerde.

53. Balzac (3) PU
Conducted in French. Prerequisite: Fr. 14 or consent of department chairman. Ms. Juka.

54. Malraux (3) PU
Conducted in French. Prerequisite: Fr. 14 or consent of department chairman. Ms. Juka.

55. Medieval French Literature (3) PU
Introduction to Old French and reading of significant texts: LaChanson de Roland, the Lais of Marie de France, Chretien de Troyes, the romances. Conducted in French. Prerequisite: Fr. 14, or consent of department chairman. Ms. Masiuk.

56. Late Medieval and Renaissance Literature (3) PU
Rabelais, Montaigne, the "Pleiade," and other poets; the "Conteurs." Conducted in French. Prerequisite Fr. 14, or consent of department chairman. Ms. Masiuk.

61. Seventeenth-Century French Literature (3) PU
A study of the main pre-classical and classical French writers of the seventeenth century. Lectures, discussion of texts, and collateral reading. Conducted in French. Prerequisite: Fr. 14 or consent of department chairman. Mr. Van Eerde.

62. Seventeenth-Century French Literature (3) PU
Continuation of Fr. 61. Conducted in French. Prerequisite: Fr. 61, or consent of department chairman. Mr. Van Eerde.

63. Eighteenth-Century French Literature (3) PU
The literature of the Enlightenment and pre-Romanticism. Lectures, discussion of texts, reports, and collateral readings. Conducted in French. Prerequisite: Fr. 14 or consent of department chairman. Mr. Van Eerde.

64. Eighteenth-Century French Literature (3) PU
Continuation of Fr. 63. Prerequisite: Fr. 63, or consent of department chairman. Mr. Van Eerde.

65. Nineteenth-Century French Literature (3) PU
Main literary currents of the nineteenth century; Romanticism and Realism. Lectures, reports, collateral readings. Prerequisites: Fr. 14 or consent of department chairman. Ms. Juka.

66. Nineteenth-Century French Literature (3) PU
Continuation of Fr. 65. Prerequisite: Fr. 65, or consent of department chairman. Ms. Juka.

67. Twentieth-Century French Literature (3) PU
A study of the principal novelists of the 20th century in France: Proust, Gide, Mauriac, Sartre, Camus, Robbe-Grillet, Beckett; with a consideration of the trends, philosophy, and movements they represent. Conducted in French. Prerequisite: Fr. 14 or consent of department chairman. Ms. Juka.

68. Twentieth-Century French Literature (3) PU
A study of the drama and poetry of twentieth-century France with readings chosen to illustrate the principal dramatists and poets as well as literary movements. Conducted in French. Prerequisite: Fr. 51-52 or consent of department chairman. Ms. Juka.

81. French Cultural Program (3-6)
A summer program abroad. Includes formal instruction in the French language as well as direct contact with the French people and their culture during two months in France.

For Advanced Undergraduates and Graduates

A student wishing to qualify for a master's degree in modern foreign languages and literature should have an undergraduate major or its equivalent in French. Those with undergraduate deficiencies, though otherwise qualified, may be admitted with the stipulation that they make up such deficiencies in addition to satisfying the minimum requirements for the degree.

The graduate major shall consist of a minimum of eighteen credit hours, fifteen of which are to be selected from the department's 400-level course offerings. The student may

choose to submit a thesis representing the equivalent of a maximum of six hours of course work. If desired, the candidate is permitted to take collateral work in related fields to the extent of twelve semester hours. At the end of the course work, the student takes a comprehensive examination.

271. Readings (3) PU
A study of the works of some author or group of authors, or of a period. Prerequisite: Fr. 14 or consent of department chairman.

272. Readings (3) PU
Continuation of Fr. 271. Prerequisite: Fr. 271 or consent of department chairman.

301. French Civilization (3)
Development of France from prehistoric times through the seventeenth century; political history, changes in social structure, literature, art. Conducted in French. Prerequisite: Fr. 51, 52 or consent of department chairman. Ms. Juka.

302. French Civilization (3)
Continuation of Fr. 301 for the eighteenth, nineteenth, and twentieth centuries. Conducted in French. Prerequisite: Fr. 51, 52 or consent of department chairman. Ms. Juka.

307. Baudelaire (3)
The major works in prose and poetry of Baudelaire with an emphasis on theme and influence. Conducted in French. Prerequisite: Fr. 51-52 or consent of department chairman. Ms. Juka.

308. Symbolism (3)
An intensive study of the symbolist school of poetry following Baudelaire through Mallarme and the end of the nineteenth century. Prerequisite: Fr. 51-52 or consent of department chairman. Ms. Juka.

309. Advanced Medieval French Literature (3)
Introduction to Old French including readings from La Chanson de Roland, Marie de France's lais, the Arthurian romances. Emphasis on the lyric poetry and the Arthurian tradition of the twelfth and thirteenth centuries. Conducted in French. Prerequisite: Fr. 51-52, or consent of department chairman. Ms. Masiuk.

311. French Classicism (3)
A study of the French classical theatre, novel, and criticism with emphasis on Corneille, Racine, Moliere, Madame de Lafayette, Malherbe, and Boileau. Conducted in French. Prerequisite: Fr. 51-52 or consent of department chairman. Mr. Van Eerde.

312. French Classicism (3)
Continuation of Fr. 311. Conducted in French. Prerequisite: Fr. 311 or consent of department chairman. Mr. Van Eerde.

313. The Age of Enlightenment (3)
A study of the "Philosophes" and "Encyclopedistes" of the eighteenth century, with emphasis on Voltaire, Rousseau, Montesquieu, and Diderot. Conducted in French. Prerequisite: Fr. 51-52 or consent of department chairman. Mr. Van Eerde.

314. The Age of Enlightenment (3)
Continuation of Fr. 313. Conducted in French. Prerequisite: Fr. 313 or consent of department chairman. Mr. Van Eerde.

317. The Romantic Movement (3)
A study and analysis of the Romantic movement in France with readings chosen from its principal exponents. Conducted in French. Prerequisite: Fr. 51-52 or consent of department chairman. Ms. Juka.

318. Theatre in the Twentieth Century (3)
Contemporary French drama with an analysis of its origins and movements. Conducted in French. Prerequisite: Fr. 51-52 or consent of department chairman. Ms. Juka.

319. The New Novel (3)
A study of current trends in the novel in France with representative readings. Conducted in French. Prerequisite: Fr. 51-52 or consent of department chairman. Ms. Juka.

323. From the Romantic Novel to the Present (3)
Stendhal, Balzac, Flaubert, Proust, Gide, Malraux, Sartre, Camus, Robbe-Grillet. Conducted in French. Prerequisite: Fr. 51-52, or consent of department chairman. Ms. Juka.

331. French Poets of the Twentieth Century (3)
The leading poets from Valery to Bonnefoy. Conducted in French. Prerequisite: consent of department chairman or two semesters of French literature in college. Ms. Juka.

333. The Great Women Writers of France (3)
Women writers of France from the Middle Ages to the present. Conducted in French. Prerequisite: consent of department chairman or two semesters of French literature in college. Mr. Van Eerde.

381. French Cultural Program (3-6)
A summer program in France offering formal language courses and cultural opportunities to graduate students and teachers of French.

402. Surrealism to Structuralism (3)
Breton, Aragon, Sartre, Camus, Levy-Strauss. Conducted in French. Prerequisite: a 300-level course or equivalent, or consent of department chairman. Ms. Juka.

411. Voltaire (3)
Representatives readings. Conducted in French. Prerequisite: a 300-level course or equivalent, or consent of department chairman. Mr. Van Eerde.

412. Stendhal and Flaubert (3)
The major works of Stendhal and Flaubert with particular consideration to style, theme and influence. Conducted in

French. Prerequisite: 300-level course or equivalent, or consent of department chairman. Ms. Juka.

415. Proust and Gide (3)
Selected readings in Proust and Gide with particular consideration to style, theme, and influence. Conducted in French. Prerequisite: a 300-level course or equivalent, or consent of department chairman. Ms. Juka.

416. Sartre and Camus (3)
A study of the plays and novels of Sartre and Camus with particular consideration to their philosophies and relation to the current literary trends. Conducted in French. Prerequisite: a 300-level course or equivalent, or consent of department chairman. Ms. Juka.

417. Moliere (3)
A study of Moliere's most significant plays with special reference to staging, technique, and influence. Conducted in French. Prerequisite: consent of department chairman or a 300-level course in French literature. Mr. Van Eerde.

418. Writings of Jean-Jacques Rousseau (3)
An emphasis on Rousseau and pre-Romanticism. Conducted in French. Prerequisite: a 300-level course or equivalent, or consent of department chairman. Mr. Van Eerde.

420. Surrealism (3)
The contributions of Breton, Aragon, Eluard, Desnos and others. Relations between painting and poetry. Conducted in French. Prerequisite: consent of department chairman or a 300-level course in French literature. Ms. Juka.

422. French Satirical Literature (3)
A survey from the Middle Ages to the present. Conducted in French. Prerequisite: consent of department chairman or a 300-level course in French literature. Mr. Van Eerde.

424. Rabelais and Montaigne (3)
The principal works of Rabelais, and the *Essais* of Montaigne. Emphasis upon concepts of "renaissance" and "humanism." Conducted in French. Prerequisite: a 300-level course or equivalent, or consent of department chairman. Ms. Masiuk.

491. Independent Study (1-3)
Special topics to supplement other study for the master of arts degree. Conducted in French. Prerequisite: a 300-level course or equivalent, or consent of department chairman.

492. Independent Study (1-3)
Special topics to supplement other study for the master of arts degree. Conducted in French. Prerequisite: a 300-level course or equivalent, or consent of department chairman.

German

Major Program

Twenty-four credits beyond German 12, of which at least nine are required at the 300 level.

Minor Program

Fifteen credits beyond German 12. At least nine credits are required at the 200-300 level; of these nine, at least three must be at the 300 level.

Spring Semester in Germany

Qualified students with junior standing or higher are eligible to participate in Lehigh's Spring Semester in Germany. After five weeks of introductory study in Hamburg (German 101, 103) and an intensive language course in Bonn (German 102), participants become full-time students during the semester from April 15 to July 15 at the University of Bonn (German 111-114, 121-124, 131-134).

Undergraduate Courses

1. Elementary German (3) fall-spring
Fundamentals of German grammar; pronunciation; simple conversation and composition; reading of simple texts. No previous German required.

2. Elementary German (3) fall-spring
Continuation of German 1. Prerequisite: Ger. 1, or two units of entrance German, or consent of chairman.

11. Intermediate German (3) fall-spring
Review of grammar; composition; reading and discussion of intermediate texts. Prerequisite: Ger. 2 or two units of entrance German or consent of chairman.

12. Intermediate German (3) fall-spring
Continuation of Ger. 11. Prerequisite: Ger. 11 or consent of chairman.

51. German Literature in Translation (3) PU
Study of a selected period or theme in German literature. Conducted in English. Does not count as a language course.

61. German for Science, Business and Industry (3)
Development of a practical knowledge of German through reading, discussion, and translation of representative texts. Prerequisite: Ger. 12 or equivalent, or consent of chairman.

63. Introduction to German Culture (3) PU
Lectures, readings, and discussion of selected aspects of German culture. Prerequisite: Ger. 12 or equivalent, or consent of chairman.

65. Introduction to the German Literary Tradition (3) PU
Study of representative works from the major periods of German literature. Prerequisite: Ger. 12 or equivalent, or consent of chairman.

Spring semester courses in Germany (Ger. 101 through Ger. 134):

101. The European Drama (3)
Readings and theater performances in Hamburg. Prerequisite: three semesters of college German or the equivalent. This course must be taken concurrently with Ger. 103.

102. Conversation and Composition in Germany (4)
Intensive practice with group discussion on selected cultural, historical and political topics. Prerequisite: Ger. 101 or its equivalent.

103. Supplemental Language Practice (1)
Prerequisite: three semesters of college German or the equivalent. This course must be taken concurrently with Ger. 101.

111, 112, 113, 114. Humanities in Germany (1-4 each)
Formal participation in approved courses in some branch of the humanities for a semester at the University of Bonn. Prerequisite: Ger. 102 or its equivalent.

121, 122, 123, 124. Social Sciences in Germany (1-4 each)
Formal participation in approved courses in some branch of the social sciences for a semester at the University of Bonn. Prerequisite: Ger. 102 or its equivalent.

131, 132, 133, 134. Sciences in Germany (1-4 each)
Formal participation in approved courses in some branch of the sciences for a semester at the University of Bonn. Prerequisite: Ger. 102 or its equivalent.

141. Development of the German Lied since the 18th Century (3) PU
Special emphasis on the intimate relationship between the music and the text. Knowledge of German very desirable but not required. Conducted in English. Prerequisite: Ger. 2 or consent of chairman. Mr. Gardner.

For Advanced Undergraduates and Graduates

A student wishing to qualify for a master's degree should have an undergraduate major or its equivalent in German. Those with undergraduate deficiencies, though otherwise qualified, may be admitted with a stipulation that they make up such deficiencies, in addition to satisfying the minimum requirements for the degree.

The successful completion of ten semester courses (thirty credit hours) is required for the master of arts degree. A thesis may be offered in lieu of two semester courses (six credit hours). Collateral graduate work in other departments may be taken upon consultation with the department chairman.

The prerequisite for all 200 and 300 courses offered in German is one course beyond the intermediate level, or equivalent, or consent of chairman.

213. Introduction to the German Lyric (3) PU
Study of the nature of the lyric as a genre of literature with readings chiefly in the lyric poetry written during the Age of Goethe (from Klopstock to the Romantics), but also with the reading of poems by some representative poets from the earlier periods of German literature. Mr. Gardner.

218. Eighteenth-Century German Literature (3) PU
Survey of major works of the Enlightenment, Sturm und Drang, and the Classical Period. Mr. Waldenrath.

220. Twentieth-Century German Literature (3) PU
Survey from Naturalism up to the present. Introduction to literary innovations of the twentieth century, and study of leading German, Austrian and Swiss writers. Mr. Hye.

233. Pennsylvania German Culture (3) PU
Study of the cultural contributions of Pennsylvania Germans: their history, literature, art, music, and politics. Conducted in English. Mr. Waldenrath.

250. Special Topics (1-3)
Study of literary and linguistic topics not covered in regular courses. May be repeated for credit.

301. Middle High German (3)
Introduction to the language and readings in medieval literature. Mr. Gardner.

303. German Romanticism (3)
Early and late Romanticists. Mr. Waldenrath.

305. German Literature from Naturalism to Expressionism (3) alternate years
Study of works by representative writers from 1885 to 1925. Mr. Gardner.

313. German Literature and World Literature (3)
A study of the interrelationships between German literature and other great literatures of the modern western world, showing how German literature influenced and was influenced by English, French, Italian, Spanish, Russian and Scandinavian literature from Goethe to the Expressionists. Lectures in English. Mr. Gardner.

321. Nineteenth-Century German Literature (3) alt. yrs.
A study of representative writers from the end of Romanticism up to Naturalism (1830-1885).

322. History of the German Language (3)
The development of the language and its present structure.

323. Science and Morality in Modern German Literature (3) alternate years
Study of the literature depicting the conflict between the scientist's desire to uncover the secrets of his or her world and the moral and philosophical implications or his or her findings. Mr. Hye.

341. Advanced Conversation and Composition (3) alt. yrs.
For undergraduates and teachers.

344. The Age of Goethe (3)
Selected works from Klopstock to Holderlin, with special emphasis on Herder, Goethe and Schiller. Mr. Waldenrath.

345. Goethe's Faust (3)
Readings of Goethe's play with an introduction to the Faust tradition.

352. Survey of Older German Literature (3)
Older German literature from the beginnings through the Baroque.

421. Renaissance and Baroque (3)
German literature from *Der Ackermann aus Bohmen* to the Age of Enlightenment.

431. Lessing and the Enlightenment (3)
Discussion and analysis of the literature in the pre-Classical Age. Mr. Waldenrath.

451. 19th Century German Lyric Poets (3)
Study of the lyric poetry form Heine through C. F. Meyer. Mr. Gardner.

452. 20th Century German Lyric Poets (3)
Study of lyric poetry from Nietzsche and Liliencron through the Expressionists. Mr. Gardner.

461. Twentieth Century Prose (3)
Study of German prose from Naturalism to the present. Mr. Hye.

462. Twentieth Century Drama (3)
Study of leading German, Austrian, and Swiss dramatists from Naturalism to the present. Mr. Hye.

471. Independent Study (3)
Research of an author or area of German literature.

472. Independent Study (3)
Research of an author or area of German literature.

Italian

1. Elementary Italian (3) fall, alternate years
Grammar; composition; rapid reading of easy modern prose. No previous study of Italian required. Mr. Van Eerde.

2. Elementary Italian (3) spring, alternate years
Continuation of Ital. 1. Prerequisite: Ital. 1. Mr. Van Eerde.

11. Intermediate Italian (3)
The age of Dante. Lectures in English on Dante and his contemporaries; readings in the *Divina Commedia*. Prerequisite: one year of college Italian or two units of entrance Italian. Mr. Van Eerde.

12. Intermediate Italian (3)
The Romantic Period: lectures in English, and selected readings from the works of Manzoni and Leopardi. Prerequisite: one year of college Italian or two units of entrance Italian. Mr. Van Eerde.

Russian

1. Elementary Russian (3) fall
Classroom and laboratory introduction to the fundamentals of conversational and grammatical patterns; practice in pronunciation, simple conversation, reading and writing. Mrs. Herz.

2. Elementary Russian (3) spring
Continuation of Russian 1. Prerequisite: Russian 1 or two units of entrance Russian. Mrs. Herz.

11. Intermediate Russian (3) fall
Classroom and laboratory practice in conversation. Development of reading and writing skills. Prerequisite: Russian 2, or three units of entrance Russian, or consent of chairman. Mr. Gardiner.

12. Intermediate Russian (3) spring
Continuation of Russian 11. Prerequisite: Russian 2 or 11, or three units of entrance Russian, or consent of chairman. Mr. Gardiner.

31. Russian in Science, Economics, and Industry I (3) fall
Readings and conversations about non-literary topics including the social and natural sciences, business, economics, industry. Prerequisite: Russian 12 or consent of chairman. Mr. Gardiner.

32. Russian in Science, Economics, and Industry II (3) spring
Continuation of Russian 31. Prerequisite: Russian 12, or 31, or consent of chairman. Mr. Gardiner.

41. Conversation and Composition (3) fall
Intensive practice in oral and written Russian; laboratory practice in aural comprehension. Readings and discussions on Russian literature and culture. Prerequisite: Russian 12, or three units of entrance Russian, or consent of chairman. Mr. Gardiner.

42. Conversation and Composition (3) spring
Continuation of Russian 41. Prerequisite: Russian 41 or consent of chairman. Mr. Gardiner.

61. Russian Literature and Culture, A (3) PU fall, alt. yrs.
Study of major customs, institutions and literary contributions to western civilization. No knowledge of Russian required. Mrs. Herz.

62. Russian Literature and Culture, B (3) PU spring, alt. yrs.
Continuation of Russian 61. No knowledge of Russian required. Mrs. Herz.

251. Special Topics (3) PU
Intensive study of literary or linguistic topics. Prerequisite:

Russian 42, or consent of chairman of department.

252. Special Topics (3) PU
Continuation of Russian 251. Prerequisite: Russian 251, or consent of chairman of department. Mrs. Herz.

341. Russian Realism (3) fall, alt. yrs.
Selected works by the Russian realists of the nineteenth century including Dostoevsky, Turgenev, Tolstoy. Lectures and class discussion in English; collateral reading and written reports either in Russian or in English. No knowledge of Russian is required. Mrs. Herz.

343. Contemporary Soviet Literature (3) spring, alt. yrs.
The development of socialist realism in Russian literature since 1917. Lectures and class discussion in English; collateral reading and written reports either in Russian or in English. No knowledge of Russian is required. Mrs. Herz.

Spanish

Required Preliminary Courses

Span 1	Elementary Spanish (3)
Span 2	Elementary Spanish (3)
Span 11	Intermediate Spanish (3)
Span 12	Intermediate Spanish (3)

Required Courses in Major

Twenty-four hours above Spanish 12 of which at least six are from courses at the 200 or 300 level.

Undergraduate Courses

1. Elementary Spanish (5) fall
Basic conversational Spanish illustrating essential grammatical principles, reading of simple texts and writing.

2. Elementary Spanish (3)
A continuation of Spanish 1. Prerequisite: Span. 1 or consent of section head.

11. Intermediate Spanish (3)
Practice in speaking and writing of topics affording an opportunity to master the current idiom through the use of materials of contemporary interest. Grammar review. Prerequisite: Span. 2 or consent of section head.

12. Intermediate Spanish (3)
Continuation of Span. 11. Emphasis on readings and discussion. Prerequisite: Span. 11 or consent of section head.

13. Development of Language Skills (3) fall
Pronunciation drills; contact with native speakers from different parts of the Spanish-speaking world; use of language laboratory facilities; participation in class discussions on themes of contemporary interest. Prerequisite: Span. 12 or consent of section head. Ms. Lefkowitz.

51. Cultural Evolution of Spain (3) PU fall
The historical and cultural evolution of Spain from its beginning to the present. Conducted in Spanish. Prerequisite: Span. 12 or consent of section head. Mr. Valenzuela.

52. Cultural Evolution of Latin America (3) PU spring
The historical and cultural evolution of Latin America. Conducted in Spanish. Prerequisite: Span. 51 or consent of section head. Mr. Valenzuela.

62. Women Writers of Latin America (3) PU spring, alt. yrs.
An examination of the contributions of women writers to Latin American literature. Conducted in Spanish. Prerequisite: Span. 12 or consent of section head. Mr. Valenzuela.

271. Independent Study (3)
A study of the works of some author or group of authors or of a period. Prerequisite: consent of section head.

272. Independent Study (3)
A study of the works of some author or group of authors or of a period. Prerequisite: consent of section head.

301. The Spanish Essay (3) alternate years
Reading and discussion of outstanding Spanish thinkers of the twentieth century with emphasis on the works of Unamuno and Ortega y Gasset. Oral and written reports. Conducted in Spanish. Prerequisite: consent of section head or Span. 51. Mr. Valenzuela.

302. The Latin American Essay (3) alternate years
Reading and discussion of distinguished Spanish-American essayists of the twentieth century with emphasis on the works of Rodo, Vasconcelos, Vaz Ferreira, and Francisco Romero. Oral and written reports. Conducted in Spanish. Prerequisite: consent of section head or Span. 52. Mr. Valenzuela.

303. Cervantes (3) alternate years
Reading and critical study of his important works with emphasis on *Don Quijote.* Conducted in Spanish. Prerequisite: Span. 51 or consent of section head. Mr. Valenzuela.

305. Spanish Literature of the Middle Ages (3)
Reading and discussion of outstanding works such as: *El Cid, El Libro de Buen Amor, La Celestina.* Topics will vary. Conducted in Spanish. Prerequisite: Span. 51 or consent of section head. Ms. Lefkowitz.

306. Existentialism and the Latin American Novel (3) alt. yrs.
Reading and discussion of representative works of contemporary Latin American novelists. Conducted in Spanish. Prerequisite: Span. 52 or consent of section head. Mr. Valenzuela.

308. Spanish Literature Since the Spanish Civil War (3)
Reading and discussion of representative contemporary Spanish poets, playwrights and novelists. Conducted in Spanish. Prerequisite: Span. 51 or consent of section head. Ms. van der Naald.

310. Nineteenth Century Spanish Novel (3)
Realism and Naturalism in Spain. Conducted in Spanish. Prerequisite: Span. 51 or consent of section head. Ms. van der Naald.

321. Latin American Literature in Translation (3) alt. yrs.
Reading and discussion of outstanding works from the pre-Columbian period through the eighteenth century. No knowledge of Spanish is required. Spanish 321 cannot count as a language course. Prerequisite: consent of section head. Mr. Valenzuela.

322. Latin American Literature in Translation (3) alt. yrs.
Reading and discussion of outstanding works from the nineteenth century to the present. No knowledge of Spanish is required. Spanish 322 cannot count as a language course. Prerequisite: consent of section head. Mr. Valenzuela.

323. Survey of Spanish Literature (3) alternate years
Readings and discussion of outstanding works from Cid through the Golden Age. No knowledge of Spanish is required. Prerequisite: consent of section head. Ms. Lefkowitz.

324. Survey of Spanish Literature (3) spring, alt. yrs.
Reading and discussion of outstanding works from the eighteenth century to the present. No knowledge of Spanish is required. Prerequisite: consent of section head. Ms. van der Naald.

331. Spanish American Literature (3) alt. yrs.
Reading and discussion of representative works of the literature of the pre-Columbian, conquest and colonial periods. Oral and written reports. Conducted in Spanish. Prerequisite: Spanish 51 or consent of section head. Mr. Valenzuela.

332. Spanish American Literature (3) alt. yrs.
Reading and discussion of representative works of the literature of the nineteenth and twentieth centuries. Oral and written reports. Conducted in Spanish. Prerequisite: Spanish 52 or consent of section head. Mr. Valenzuela.

341. Advanced Conversational Spanish (3)
Practice in fluency and accuracy in Spanish. Prerequisite: consent of section head.

342. Advanced Spanish Composition (3)
Special attention given to syntax and style. Prerequisite: consent of section head.

351. Satirical Literature in the Late Middle Ages (3)
A historical, cultural, and literary analysis of satirical prose and poetry that flourished in the fourteenth and fifteenth centuries. Conducted in Spanish. Prerequisite: Span. 51 or consent of section head. Ms. Lefkowitz.

353. The Picaresque Novel in Spain (3)
Lectures and discussion of *Lazarillo de Tormes*; Cervantes' *Rinconete Y Cortadillo*; Quevedo's *El Buscon*. Conducted in Spanish. Prerequisite: Spanish 51 or consent of section head. Ms. Lefkowitz.

355. Improvisational Theater Games in Spanish (3) fall
For students who have some fluency in the language and who welcome an opportunity to practice and improve their spoken Spanish in the creative setting of improvisational theater games. Conducted in Spanish. Prerequisite: consent of section head. Ms. van der Naald.

357. Women Novelists and Playwrights of Latin America (3)
Reading and discussion of outstanding contemporary works by Latin American women. Conducted in Spanish. Prerequisite: Span. 51 or consent of section head. Mr. Valenzuela.

411. Twentieth Century Spanish Theater (3)
A study of the development of twentieth century theater from Galdos to the present. Conducted in Spanish. Prerequisite: a 300-level course or consent of section head. Ms. van der Naald.

412. Neruda and Mistral (3)
A study of the representative works of these authors. Conducted in Spanish. Prerequisite: a 300-level course or consent of section head. Mr. Valenzuela.

413. Ruben Dario and "Modernismo" (3)
A study of the poetry of Ruben Dario and his relation to the "Modernismo" movement. Conducted in Spanish. Prerequisite: a 300-level course or consent of section head. Mr. Valenzuela.

415. The Spanish Romancero (3)
An investigation of the traditional Spanish ballad (romance) from the fifteenth to the seventeenth century. The study of its origin, evolution, form, structure and style, in light of the medieval epic. Conducted in Spanish. Prerequisite: a 300-level course or consent of section head. Ms. Lefkowitz.

416. Spanish Theater of the 17th Century (3)
The development of the Spanish drama of the Golden Age. Conducted in Spanish. Prerequisite: a 300-level course or consent of section head. Ms. van der Naald.

417. Seminar on Galdos (3)
A study of his life and works. Conducted in Spanish. Prerequisite: a 300-level course or consent of section head. Mr. Valenzuela.

418. Seminar on Borges and Cortazar (3)
A study of the life and works of Jorge L. Borges and Julio Cortazar. Conducted in Spanish. Prerequisite: a 300-level course or consent of section head. Mr. Valenzuela.

419. Nineteenth Century Spanish Theater (3)
From Romanticism to Realism. Conducted in Spanish. Prerequisite: a 300-level course or consent of section head. Ms. van der Naald.

421. Secular Love Poetry in Medieval Spain (3)
Study of early lyric tradition, focusing on the Hispano-Hebrew-Arabic Kharchas and Galician-Portuguese Cancionero

Poets. Conducted in Spanish. Prerequisite: a 300-level course or consent of section head. Ms. Lefkowitz.

491. Independent Study (3)
Special topics to supplement other study for the M.A. degree. Conducted in Spanish. Prerequisite: a 300-level course or consent of section head.

492. Independent Study (3)
Special topics to supplement other study for the M.A. degree. Conducted in Spanish. Prerequisite: a 300-level course or consent of section head.

Music

Professor

Robert Benjamin Cutler, M.A., *Chairman*

Assistant Professors

Jerry T. Bidlack, M.A.
James E. Brown, M.A.

The department of music is primarily a performing department, offering opportunities for participation in band, choruses, ensembles and orchestra. Admission to these groups is by audition, and students receive credit by registering for the appropriate course in the series Mus. 21-68.

Although there is no limit ot the number of courses in this series which a student may take, students should check carefully with their advisors to determine the value of the courses as graduation credit. For example, a maximum of eight credits may be applied toward graduation in the College of Arts and Science. None of these may be used for the college humanities distribution requirement.

Students who study privately for credit in the Mus. 71-78 series must schedule their own lessons and make their own financial arrangements with their teachers. Arrangements for private study at Moravian College may be made through cross-registration under the Cooperative College Program. Here, too, arrangements for scheduling lessons must be made directly with the Moravian College music department. Students will be billed for their lessons by the Lehigh Bursar.

Course Information

Mus. 20 Introduction to Musical Literature is the general introductory course designed for students with no previous training. It does not teach the elements of music but pursues a historical approach to listening to music.
Mus. 81-82 Fundamentals is the course which deals with hearing, performing, and writing music. *Mus. 181-182 Composition* is, in a sense, an advanced course in Fundamentals with an emphasis on composition. The courses in *Orchestration, Mus. 149,* and *Score Reading and Conducting, Mus. 150,* are also technical music courses which require a reasonable amount of skill and experience for a student to benefit from them.

A student must be familiar with the materials of music in order to enroll in any of the courses which study and analyze musical literature: *Mus. 141 Sacred Choral Music, 142 Chamber Music, 143 Keyboard Music, 147 Opera, 148 Symphony,* and *151 Twentieth-Century Music.*

The course in *Electronic Music, Mus. 153-54,* is in a category by itself. Enrollment is limited by the size of the electronic studio and the hours of its availability.

Majors and Minors in Music

Students who wish to major in music may do so by taking a series of courses at Moravian College through the Cooperative College Program. A major concentration in Music consists of thirty credit hours, twenty-four of which shall be advanced courses. The prerequisite for all advanced courses is *Fundamentals* unless students can demonstrate that they have mastered the rudiments of music. The advanced courses must include the following four Moravian courses (three credit-hours each): *101 Music Before 1600, 102 The 17th and 18th Centuries, 103 The 19th Century* and *104 The 20th Century.* The Moravian courses below 100 and the courses in the series from 143 through 171 are elementary, not advanced courses. The remainder of the courses may be taken either at Moravian or Lehigh.

A student may minor in music by taking fifteen credit hours. The courses selected must be approved by the department chairman.

Concert Series

Music at Lehigh is a series of free professional concerts sponsored by the music department. This series of from ten to twelve concerts each year is administered by a student committee and the faculty of the department. Among the artists heard recently are the Goldovsky Opera Company, the Music for a While renaissance ensemble, soloists from the Young Concert Artists series and the Philadelphia Composers Forum. In addition to this series there are frequent concerts by Lehigh's own choral and instrumental performing groups.

Course Offerings in Music

20. Introduction to Musical Literature (3) P
An approach to musical style through the study of works by representative composers from the year 1600 to the present. Mr. Cutler.

21-28. Band (1)

31-38. Chamber Singers (1)

41-48. Ensembles (1)

51-58. Glee Club (1)

61-68. Orchestra (1)

71-78. Private Study (1)
Private instrumental or vocal study with instructors who are approved by the department. Prerequisite: consent of department chairman.

81. Fundamentals (3) P
Study of melody, harmony, rhythm, and timbre as the essential elements of music. Practical exercises in dictation, sight-singing, keyboard harmony and composition. Prerequisite: some prior knowledge of music and consent of department chairman.

82. Fundamentals (3) P
Continuation of Music 81. Prerequisite: Music 81 or equivalent.

141. Sacred Choral Music (3)
The functional aspects of choral music and its relationship to the church, beginning with Gregorian Chant. Compositions of the Renaissance and Baroque masters are studied, with special attention given to the works of Bach. A survey is made of the outstanding sacred choral works of the 18th, 19th and 20th centuries, observing the shift in emphasis from the church to the concert hall. Prerequisite: consent of department chairman. Mr. Cutler.

142. Chamber Music (3)
A survey of works for smaller instrumental ensembles from the forerunners of Haydn to Stravinsky. Prerequisite: consent of department chairman. Mr. Cutler.

143. Keyboard Music (3)
Study of keyboard music with particular reference to the styles of Scarlatti, Bach, Mozart, Beethoven, Chopin and Bartok; demonstration of performance techniques on the various instruments; description of the mechanics of keyboard instruments, such as the organ, harpsichord, and piano. Prerequisite: consent of department chairman. Mr. Cutler.

147. Opera (3)
Study of three significant operas from the standard literature. Field trips to performances when possible. Prerequisite: ability to read piano-vocal score and Music 81-82 or equivalent. Mr. Bidlack.

148. Symphony (3)
Study of symphonic literature from the 18th century to the present. Prerequisite: Music 81-82 or equivalent. Mr. Bidlack.

149. Orchestration (3)
Study of traditional orchestration practice from 1600 to the present. Practical projects in orchestration using performing groups as laboratory. Prerequisite: Music 81-82 or equivalent. Mr. Bidlack.

150. Score Reading and Conducting (3)
Building skills necessary for the study and interpretation of the music scores. Intensive work at the piano with transposition, clefs, and full score reduction. Study of basic conducting patterns. Prerequisite: consent of department chairman. Mr. Bidlack.

151. Twentieth Century Music (3)
Analysis of selected works from Debussy to the present; particular attention to post-romanticism, Stravinsky, serialism, electronic music, and the music-aesthetic of John Cage. Prerequisite: familiarity with musical notation and Music 81-82 or equivalent. Mr. Brown.

153. Electronic Music (3)
A series of projects using techniques to modify existing sounds, to create synthesized sounds, and to record sounds. Composition of tape music. Prerequisite: consent of department chairman. Mr. Brown.

154. Electronic Music (3)
Continuation of Music 153. Prerequisite: Music 153 or equivalent. Mr. Brown.

181. Composition (1-3)
Applications of the principles of Music 81-82 to compositional practice. Prerequisite: Music 81-82 or equivalent. Mr. Brown.

182. Composition (1-3)
Continuation of Music 181. Prerequisite: Music 181 or equivalent. Mr. Brown.

251. Special Topics (1-3)
Study of musical topics or work in musical composition not covered in regular courses, or continuation of study of topics or of projects in composition begun in regular courses. May be repeated for credit. Prerequisite: consent of department chairman.

Natural Science

J. Donald Ryan, Ph.D., *Chairman of Geological Sciences and director of Natural Science program*

This major provides students with a broad background in the fundamentals of mathematics and science and the opportunity to concentrate to a reasonable degree in one area of science. The program is designed especially for (1) those students who desire preparation for graduate work or careers in certain of the derivative or interdisciplinary sciences or related professional fields (oceanography, astronomy, psychophysiology, geophysics, information science, medicine or dentistry, conservation, etc.), (2) those students who plan to teach in secondary schools or community colleges, and (3) those students without fixed career objectives who desire undergraduate training in science.

Students who register for the program are required to select an area of concentration (or option) which 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 (geophysics, marine science, biochemistry, information science, etc.). Courses included in the option will be worked out individually for the student by the major advisor.

A special program leading to a bachelor of arts in natural science and a master of science in materials is available for interested students. See Five-Year Programs.

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 (M.A., M.S., or M.Ed.) during the senior year. Students enrolled in this program often will be able to complete all requirements for the master's degree with one year of study beyond the baccalaureate.

Required Preliminary Courses

Math 21, 22, 23	Analytical Geometry and Calculus (12)
Phys 11, 12	Introductory Physics I & Lab (5)
Phys 21, 22	Introductory Physics II & Lab (5)
Chem 21, 22	Introductory Chemical Principles & Lab (5)
Geol 1	Principles of Geology or
Astron 1	The Solar System (3)
Biol 21, 22	Principles of Biology or
Psych 3	Psychology as a Natural Science (3)

Required Major Courses

Chem 51, 52, 53, 54	Organic Chemistry or
Chem 91, 190	Physical Chemistry (6-10)
Math	Elective (3)
	Option (24)

Note: Math elective and courses included in option taken with the approval of major advisor.

Students registered for this major normally are expected to choose their option no later than the second semester of the sophomore year.

Philosophy

Professors

Thomas Morris Haynes, Ph.D.
Norman Paul Melchert, Ph.D.

Associate Professors

Robert Featherstone Barnes, Ph.D.
John Ralph Lindgren, Ph.D., *Chairman*

Assistant Professor

Nicholas Anthony LaPara, Ph.D.

Instructor

John Edmund Hare, B.A.

Students considering extensive study in philosophy, whether as a major, a major in conjunction with a minor in another field such as Fundamentals of Business, or as a minor, need answers to two main questions: What is the field of philosophy like? And what career possibilities are there for someone who majors or minors in philosophy? This description tries to give brief answers to these questions.

Philosophically inclined thinkers have always asked fundamental questions about the intellectual, moral, religious, social, and political aspects of human life. They have tried to subject these issues to rigorous analysis and provide thoughtful answers relevant to their time. The major current contexts for philosophical inquiry are the nature and place of moral values in contemporary life, the dysfunction of social and political institutions, the impact of technology, and the challenge of the scientific world view. These lead to such questions as: What is the relation of the individual to the state and its laws? Which human lifestyles and institutions are conceptually viable in a technological society? What are the implications of the scientific world picture for our concepts of religion, freedom, and creativity? The analysis of the component issues in these and many more problems, the unearthing of presuppositions, the proposal of answers, and the cri-

tique of those proposals are the actual elements of philosophical investigation.

The study of philosophy is excellent preparation for a variety of careers either immediately after graduation or after further study beyond the bachelor's degree. Careers requiring further study for which philosophy is an especially suitable preparation include: academic philosophy; law; some types of government service, e.g., urban planning; certain careers in business, e.g., management consulting, personnel and industrial relations; the ministry; academic careers in areas other than philosophy, e.g., intellectual history, religious studies, social and political theory, and information systems; and primary and secondary education. Students majoring or minoring in philosophy who are not considering such fields will find a wide variety of careers open to them immediately after graduation. Capable philosophy students who choose their electives wisely find that the analytical, logical, and discursive skills provided by philosophical training enable them to successfully pursue careers after graduation in such fields as communications, publishing, insurance, marketing, merchandising, social services, advertising, transportation, and utilities. This is expecially true for students who combine a major in philosophy with a minor in the Fundamentals of Business.

The curriculum of both the major and the minor in philosophy provides both ample flexibility for tailoring course work in philosophy to the developing interests of each student and wide latitude for supplementing these studies with work in other disciplines. The aim of these curricula is to enable each student, working closely with his or her departmental advisor, to develop a total curriculum in the light of their own interests and aspirations.

The minor in philosophy consists of fifteen hours of course work. The specific courses to be taken by a student in this program are decided jointly by the student and the departmental advisor. These ordinarily include at least one course at the introductory level and one at the advanced level. Minor programs may either be of a general character or organized around a special theme such as: the philosophy of science, logic, ethics and value theory, the history of philosophy, and social philosophy.

The major in philosophy consists of thirty hours of course work. Again, the specific courses to be taken by each student are decided jointly by the student and the departmental advisor. In the case of the major, the following minimum constraints are observed:

Required Courses

Phil 14	Foundations of Logic (3)
Phil 15	Ethics (3)
	plus three of the following:
Phil 131	Ancient Philosophy (3)
Phil 133	Medieval Philosophy (3)
Phil 135	17th and 18th Century Philosophy (3)
Phil 137	19th Century Philosophy (3)
Phil 139	20th Century Philosophy (3)

And fifteen hours to be selected with the counsel and approval of the departmental advisor. At least nine of these fifteen hours must be at the 300 level. Normally these will be courses in the philosophy curriculum, although substitutions of courses from other departments may be made with the approval of the advisor.

Undergraduate Courses

10. Introduction to Philosophy (3) P fall-spring
Basic philosophical questions, perennial and contemporary, such as the objectivity of morals, the justification of government, the place of mind and feeling in a world of matter and energy, the nature of knowledge and truth, and the reality of God.

11. Values, the Individual, and the State: An Introduction to Philosophical Thinking (3) P
An introductory course with two goals: (1) to explore some important current issues such as the philosophical status of democracy; the nature of violence; the metaphysics of punishment; the nature of personhood; the connection of law and morality; and (2) to acquaint the student with the sort of disciplined reflection characteristic of philosophical thought. Not available to juniors and seniors. Consent of department chairman.

13. Practical Logic (1) P fall-spring
Development of skill in analysis, criticism, and evaluation of reasoning. Emphasis on training practical ability, with material drawn from real-life contexts.

14. Foundations of Logic (3) P fall-spring
The development of several symbolic languages as theoretical models for explaining certain logical features of ordinary English discourse, such as valid inference and necessary truth. Some of the significant general properties of these symbolic languages will be studied. Messrs. Barnes or LaPara.

15. Ethics (3) P fall-spring
A critical study of classic and contemporary ethical theories as analyses of moral life. Special attention is given to problems concerning the nature of moral responsibility and moral judgment, the relation of man to his world, and the scientific status of moral theory.

42. The Scientific Process (3) P spring
Study of the generation and acceptance of scientific concepts and laws, especially the contributions of theory, metaphysics, and value. Case studies in the history of science illustrate the logic of this intellectual activity. Mr. LaPara.

100. Philosophy of Contemporary Civilization (3) P fall-spring
A philosophical analysis of the theoretical foundations of our culture, providing a useful method for formulating policies in private and public life. Special attention is given to the nature and integration of ideals of family, industry, education, art, science, religion, law, and politics. Mr. Haynes.

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. Mr. Hare.

133. Medieval Philosophy (3) alternate years
Historical study of philosophy from the fall of 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. Mr. Hare.

135. 17th and 18th Century Philosophy (3) alternate years
Historical study of the major philosophers from the Renaissance to the end of the eighteenth century; the work of Descartes, Spinoza, Leibniz, Locke, Berkeley, Hume, Rousseau, and Kant. Special attention will be given to the interaction of political, scientific, and philosophical thought during the period. Mr. Lindgren.

137. 19th Century Philosophy (3) fall
Historical study of the major philosophers of the last century, including Mill, Hegel, Feuerbach, Marx, and Nietzsche. Special emphasis will be given to the interaction of the philosophic, social, and political life of the period. Mr. Lindgren.

139. 20th Century Philosophy (3) spring
Trends in philosophical thought during this century: pragmatism, positivism, linguistic analysis, existentialism, and Marxism. Attention to how recent philosophers have treated such enduring topics as truth and knowledge, values and moral judgment, meaning, the place of the individual in the physical world and in society, and the impact of scientific methodology on all of these. Mr. Melchert.

143. Kierkegaard (1) spring
An introduction to the life and thought of Søren Kierkegaard, the 19th-century Danish forerunner of existentialism, with a brief look at his impact on philosophy, theology, psychology and literature. Mr. Melchert.

144. Karl Marx (1) fall
Introduction to the life and writings of Karl Marx, with special attention to his analyses of alienation, capitalism, history, revolution, and the Communist movement. Mr. Lindgren.

150. (Engl. 150) Media and Values (3) alternate years
How media and values are formed and reformed by their mutual interaction. Combines humanistic criticism with philosophical analysis to study a considerable range of the principal media (the human body, language, film, television, architecture, art) through which human values arise and take their place in the world. Historical, existentialist, phenomenological, and structuralist analyses are stressed. Individual student projects in media-value analysis or manipulation are required. Messrs. Haynes and MacDonald.

For Advanced Undergraduates and Graduates

251. Reason and Religious Experience (3) fall
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. Mr. Melchert or Mr. Hare.

261. Introduction to Philosophy of Science (3) fall
Analysis of the structure and foundations of scientific knowledge. Topics such as explanation, empirical significance, operationalism, theory and observation, confirmation, and induction are investigated. Mr. LaPara.

264. Meaning (3) alternate years
Investigation of the problem of how language, a conventional and arbitrary structure of symbols, can be a vehicle of meaning. Theories of meaning, such as the referential, picture, behavioristic, and speech act theories are discussed. Mr. LaPara.

271. 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 department chairman.

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 department chairman.

301. Philosophy of the Social Sciences (3) spring
An analysis of the social sciences considered as programs for achieving understanding and control of man and society. Study is made of assumptions basic to, and problems incurred in, scientific methodology in general; the implications of these for the various social sciences are stressed. Mr. Haynes.

302. Value Theory (3)
Consideration of types of value and modes of value judgment, evidence and authority in value judgments, techniques of normative analysis, and the relation of value judgments to science. Exemplification of these issues will be made in such fields as psychology, economics, political science, morality, law, art and religion. Mr. Haynes.

310. Social Philosophy (3) alternate years
An analysis of the conditions for and consequences of the existence of a society among men. The primary objective of this course is to show what a society is and what it means to be a member of a society. Attention is devoted to such issues as obligation, authority, justice, freedom, equality, social institutions, social choice, social change, and the problem of sustaining the social dimension of human existence. Readings in contemporary social philosophy emphasized. Mr. Lindgren.

314. Logical Theory (3) alternate years
Conceptual foundations and philosophical significance of classical and modern logical theories. Analysis of the syntactic and semantic methods in logic, and their interrelations. Philosophical impact of important technical results, including Goedel's Incompleteness Theorem. Some discussion of potential future developments and alternative logics. Prerequisite: Phil. 14 or consent of department chairman. Mr. Barnes.

315. Contemporary Ethics (3) alternate years
An examination of recent literature on selected topics such as moral relativism, the role of reason in morality, conscience and the law. Prerequisite: Phil. 15 or consent of department chairman. Mr. Melchert.

350. Minds and Bodies (3) alternate years
Investigation of consciousness in the light of what is known about brains and behavior. The nature and status of sensations, thinking, intentional actions, free choice, and the self are discussed. Mr. Melchert.

362. Science and Subjectivity (3) alternate years
Consideration of contemporary attacks on the claims of science to objective knowledge. Examination of the arguments that scientific belief rests irreducibly on faith in subjective presuppositions, metaphysical commitments, or assumptions that cannot be based on evidence. Mr. LaPara.

391. Advanced Topics in Philosophy (1-3)
Examination of selected topics for philosophy majors and minors and other advanced students. Prerequisite: consent of department chairman.

Division of Information Science

Professors

Donald John Hillman, M.Litt., *Director, Center for Information Science*
John J. O'Connor, Ph.D.
Herbert Rubenstein, Ph.D.

Associate Professors

Robert Featherston Barnes, Ph.D., *Head, Division of Information Science*
Andrew James Kasarda, Ph.D.

New developments in information technology are providing new methods and opportunities to cope with long-standing problems of providing access to needed information and screening out unwanted material. The Division of Information Science offers courses to help hard-pressed information users with their information problems and to provide background and training for those who wish to devote a substantial portion of their professional careers to areas of information science.

On the undergraduate level, a minor in information science is available, consisting of twenty-one hours of approved courses, including IS 11 (Computer Programming in the Humanities and Social Sciences). The minor can be structured either as a survey of various areas of computer and information science or as a concentration on a specific topic. An example of the former might consist of IS 11, 110, 202, 321, IE 309, 310, and EE 315. A minor of the latter sort, focussed on human linguistic information processing, might consist of EE 11, IS 201, IS 203, IS 301, IS 302, IS 320, and IS 324. The specific content of a particular program will be chosen in consultation with the student's advisor, based on the student's own needs and goals.

On the graduate level, both M.S. and Ph.D. programs are offered. These aim at providing practitioners in areas of information science and technology the strong conceptual background necessary to keep pace with rapid changes in the field. Each program provides a base of both theory and application, with emphasis on fundamentals, rather than simply on techniques. Basic to both programs is the concept that research and instruction reinforce each other. Consequently, whenever possible, students are expected to participate in research activities.

The curriculum in information science is based on a B.S. degree in an engineering or scientific discipline. Desirable preparation consists of at least twelve hours of mathematics, including nine hours of differential and integral calculus and one course beyond the calculus. In recognition of the flexibility and cross-disciplinary nature of the subject, exception to this requirement may be granted to those students with training in a systematic science. A course in computer programming or programming experience is desirable. Mathematics 105, Computer Programming, is available, without graduate credit, for those without computer background.

A candidate for the degree of master of science in information science is required to complete at least twenty-four hours of approved course work and to submit a thesis. Each student's schedule will be chosen in consultation with the head of the division. Three core areas are at the heart of the M.S. program: information processing systems; information retrieval theory; and analysis of information. Beyond this basic core, student schedules are planned on an individual basis to fit previous academic experience and career goals. Depending upon the candidate's background and interests, emphasis can be either in theoretical or applied directions.

The division also participates in the University's interdepartmental M.S. program in computer science. Requirements for that program can be found on page 70.

Maximum advantage is taken of courses in other departments on the campus. Consequently a student's program will be a combination of courses in information science, together with offerings by the departments of electrical engineering, industrial engineering, mathematics, psychology, social relations, and others.

The Ph.D. in information science covers such diverse topics as mathematical logic, information systems, command and control systems, computer programming, computer languages, systems analysis, operations research, computational linguistics, probability theory, statistics and statistical inference, switching theory, graph theory, algebra, topology, automata theory, and artificial intelligence. The division of information science has ongoing programs of research and development and offers opportunities for well-qualified students to participate in such projects. In these research and development activities, the division cooperates closely with the Center for Information Science and the Mart Library of Science and Engineering.

A candidate for the Ph.D. degree is required to submit a general plan to the chairman of the department at the beginning of the first year of doctoral studies. This plan must be

approved by the candidate's special committee at the time of his or her admission to candidacy.

The doctoral program in information science will be based on the candidate's approved plan of original and specialized research. A program of courses and seminars at the 400 level will also be formulated in the field in which the dissertation is to be written.

11. Computer Programming for the Humanities and Social Sciences (3) fall
An introduction to computer programming with special emphasis on the requirements of language-oriented applications. FORTRAN will be taught for basic quantitative manipulations, and SNOBOL 4 for qualitative purposes. The course will stress the importance of defining and formulating problems via flow charts. No previous knowledge of computer programming is required. Mr. Hillman.

12. Computer Applications in the Humanities and Social Sciences (3) spring
Applications of computers to studies in the humanities and social sciences to obtain greater rigor and sophistication. Both quantitative and qualitative applications will be covered, but special attention will be given to recent developments of the latter sort, since these applications are often the more significant ones. Prerequisite: I.S. 11, or its equivalent. Mr. Hillman.

110. (Math. 110) Algorithmic Processes (3)
The role of machines as abstract models of physical processes. Computability, practical computability, and unsolvability. Examples such as recursive function theory and the computable real number system. Prerequisite: Math. 23 or Math. 32. Mr. Barnes.

201. Computers and Language (3) offered as required
The role of computers in such activities as natural language processing, mechanical translation, speech recognition, and augmentation of human reasoning.

202. Computers and Society (3) spring
A general nontechnical survey of the impact of computers on modern society. Special attention will be 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.

203. Survey of Language Sciences (3) offered as required
A general survey of the major fields of language study: descriptive and historical linguistics, psycholinguistics, sociolinguistics, computer applications, statistical linguistics, stylistics. Mr. Rubenstein.

301. Descriptive Lingnistics (3)
Techniques for the description of the phonology, morphology, and syntax of natural languages. Special attention to transformational generative grammar. Mr. Rubenstein.

302. (Psych. 320) Psycholinguistics (3)
Study of the experimental and observational literature on the production and comprehension of utterances and on the acquisition of language. Consideration of performance of the language user. Mr. Rubenstein.

306. Statistical Linguistics (3)
A study of statistical properties of natural language usage. Data sources, measurement techniques and applications will be examined. Some competence in applied statistical analysis will be assumed. Offered as required.

317. (E.E. 317) Analytical Methods for Information Sciences (3)
For description see E.E. 317.

320. (Psych. 308) Information Processing: Human and Machine (3) alt. yrs.
Study of the identification, storage, retrieval and use of auditory and visual inputs in decision-making contexts. Human and mechanical information processes, their similarities and differences. Mr. Rubenstein.

321. Introduction to Information Methodology (3)
History, theory, and structure of indexing and classification systems for the organization of information; comparative analysis of selected retrieval schemes; experimental methods for developing indexing systems and analyzing subject content.

324. Development and Decline of Human Information Processing Abilities (3)
The study of perception, storage, retrieval, use and communication of information as these abilities develop in the child and decline as a result of brain injury, mental disorder, or senility. Special attention will be paid to correlations between the ability to use language and the ability to perform other cognitive tasks.

330. Low-Cost Personal Retrieval Systems (3)
Retrieval systems applicable to personal information collections gathered for study, research, hobby, or other purposes. Experimental study, each student working with his or her personal information collections. Emphasis on systems requiring no mechanical devices. Also some study of computerized systems. Mr. O'Connor.

361. Automata and Formal Grammars (3)
Study of the interaction between recognition devices and generation devices for formal languages. Comparison of automata and formal grammars of differing strengths. Application to questions of computability and decidability. Mr. Barnes.

362. (Math. 362) Computer Languages (3)
For description see Math. 362.

374. Information Retrieval Theory (3)
An introduction to the problems of computerized information storage and retrieval systems. Special attention is given to the logical and mathematical techniques for automatic text-processing, file generation, and inquiry negotiation.

379. Introduction to Library Organization (3) offered as required
An introduction to libraries as information organizations, including their history, function, and structure. This course is intended to supply a frame of reference for those students intending to take I.S. 380, Library Automation; and to provide a background for students interested in broad applications of information science to social and educational needs.

380. Library Automation (3) offered as required
A study of methods and procedures in the application of automated equipment in libraries. Special attention is given to the augmentation of acquisition, cataloging, circulations and reference functions. Prerequisite: I.S. 379 or consent of chairman.

390. Special Topics (1-3) offered as required
An opportunity for advanced work through supervised reading and research. Prerequisite: consent of chairman. May be repeated for credit.

402. (Psych. 448) Seminar in Psycholinguistics (3)
Selected topics in psycholinguistics examined in depth and in detail. Prerequisite: I.S. 301.

418. Special Topics in Linguistics (3) offered as required
Selected topics in linguistics not covered in other courses. Mr. Rubenstein.

422. Analysis of Information Systems (3)
The study of the organization of information systems with respect to design criteria, information acquisition and entry, information processing, classification and storage, retrieval and dissemination, feedback control and evaluation; operational requirements such as hardware, software and personnel, and system economics. Mr. Kasarda.

431. Subject Document Retrieval (3)
Technique and systems for retrieval of documents in response to subject requests. Fundamental ideas, achievements to date, problems and possibilities. Topics covered include request negotiation techniques, document indexing (coordinate, relational, weighted), "Boolean" and weighted term searching methods, and thesauri and classifications as aids to negotiation, indexing, and searching. Mr. O'Connor.

432. ALP-Aided Document Retrieval (3)
Subject document retrieval aided by automatic language processing (ALP). Fundamental ideas, achievements to date, problems and possibilities. Topics covered include computer and man-machine performance of the following functions: subject indexing and classification of documents, abstracting, construction of thesauri and classification of schedules, retrieval by searching natural language text of unindexed documents, and on-line negotiation of retrieval requests. Prerequisite: I.S. 431 or equivalent. Mr. O'Connor.

433. (E.E. 403) Design of Executive Systems (3)
For description see E.E. 403.

442. Evaluation Models (3) offered as required
An investigation of the activities necessary to the development of formal structures for evaluating complex systems. Particular treatment is directed toward the evaluation of large information retrieval systems. Topics covered include establishment of system objectives, recognition and isolation of variables, economic aspects, empirical testing.

450. Information Network Theory (3) offered as required
Applications of graph theory to the modeling, simulation, and design of information networks. Prerequisite: I.S. 374.

462. Retrieval Languages (3) alternate years
The study of formal indexing and retrieval languages, with special attention to the interaction between syntactic structure and retrieval properties. Examples will be drawn from actual and experimental systems to show the effect of syntactic structure upon system capabilities. Mr. Barnes.

466. Topics in the Theory of Automata and Formal Grammars (3) alternate years
Advanced study of automata-theoretic approaches to questions of computability, decidability, acceptability, and generability. May be repeated for credit. Prerequisite: I.S. 361 or consent of chairman. Mr. Barnes.

481. Thesis (3)

482. Thesis (3)

492. Special Topics in Information Science (3) offered as required
Selected topics in the information sciences not covered in other courses.

Physics

Professors

James Alan McLennan, Ph.D., *Chairman*
Raymond Jay Emrich, Ph.D.
Robert Thomas Folk, Ph.D.
Wyman Beall Fowler, Ph.D.
Sheldon H. Radin, Ph.D.
Wesley Richard Smith, Ph.D.
Wesley Johnson VanSciver, Ph.D.

Associate Professors

Brent W. Benson, Ph.D.
Ernest E. Bergmann, Ph.D.
Garold J. Borse, Ph.D.
Frank J. Feigl, Ph.D.
Alvin S. Kanofsky, Ph.D.
Yong Wook Kim, Ph.D.
Russell A. Shaffer, Ph.D.
Donald B. Wheeler, Jr., Ph.D.

Assistant Professors

Colin E. Jones, Ph.D.
Jeffrey A. Sands, Ph.D.

Physics deals with the nature of actual things and events: matter, space and time. Summaries of observations in the form of laws are formalized into theories of mechanics, heat, electricity and magnetism, gravitation, structure of bulk matter, structure of atoms and nuclei, and elementary particles.

A physics student studies theories of physics and techniques of experimental physics. If the student chooses a career as a professional physicist, he or she will probably continue studies in graduate school*, and then work in industrial research or in university or college teaching and/or research. The individual may become involved in the discovery of basic principles and new phenomena, or may join the many physicists who contribute to the development of advanced technologies and applications based on physics. Alternatively, the bachelor's degree student may choose to enter an area of science or engineering bordering on physics, either through graduate school in a nonphysics program or through employment immediately after graduation. Since physics is basic to other sciences and engineering, the physics program provides a background with broad flexibility for later activities.

Students in the College of Engineering and Physical Sciences or the College of Arts and Science may major in physics leading to the bachelor of science in engineering physics or the bachelor of arts with a major in physics, respectively. The bachelor of arts and bachelor of science programs are nearly identical in their physics and mathematics requirements, with the differences being due mainly to different college requirements. The bachelor of arts curriculum in the College of Arts and Science includes the college's distribution requirements, whereas the bachelor of science curriculum in the College of Engineering and Physical Sciences includes the course Engineering 1 - Introduction to Engineering Problems, and that college's general study requirements.

Students may transfer quite easily from one program to the other, often as late as the fourth year. While the two programs have similar technical requirements, it is usually found that the choice of electives reflects a natural bias; for example, the B.S. candidate normally elects more engineering courses than the B.A. candidate. In any case, the student planning on employment immediately after graduation is urged to select electives from courses in other sciences or engineering so as to broaden his or her knowledge of the applications of physics.

*Students are advised that admission to graduate school requires a minimum grade average, with a minimum average of B being typical. Also, many graduate schools require a reading knowledge of a modern foreign language.

Physics Major in College of Arts and Science

Required Preliminary Courses

Chem 21, 22	Principles of Chemistry (8)
Math 21, 22, 23	Analytical Geometry and Calculus (12)
Phys 11, 12	Introductory Physics I & Lab (5)
Phys 21, 22	Introductory Physics II & Lab (5)

Required Major Courses

Phys 31	Introduction to Quantum Mechanics (3)
Phys 90	Electrical Phenomena (1)
Phys 171	Proseminar (1)
Phys 191	Laboratory Techniques (2)
Phys 212	Electricity and Magnetism I (3)
Phys 213	Electricity and Magnetism II (3)
Phys 215	Particles and Fields I (3)
Phys 216	Particles and Fields II (3)
Phys 254	Optics Laboratory (2)
Phys 340	Heat, Thermodynamics and Pyrometry (3)
Phys 362	Atomic and Molecular Structure (3)
Math 219, 220	Principles of Analysis (6)
Math 205	Linear Methods (3)
	Approved Electives (8)

Engineering Physics Curriculum in College of Engineering and Physical Sciences

Freshman Year (See page 52)

Sophomore Year, First Semester (15 credit hours)

Phys 21, 22	Introductory Physics II & Lab (5)
Math 23	Analytical Geometry and Calculus III (4)
	G.S. Requirement (3)
	Elective (3)

Sophomore Year, Second Semester (17 credit hours)

Phys 31	Introduction to Quantum Mechanics (3)
Phys 90	Electrical Phenomena (1)
Math 205	Linear Methods (3)
Eco 1	Economics (4)
	Electives (6)

Junior Year, First Semester (14-17 credit hours)

Phys 191	Laboratory Techniques (2)
Phys 212	Electricity and Magnetism I (3)
Phys 215	Particles and Fields I (3)
Math 322	Methods of Applied Analysis I (3)
	Electives (3-6)

Junior Year, Second Semester (17 credit hours)

Phys 254	Optics Laboratory (2)

Phys 213	Electricity and Magnetism II (3)
Phys 216	Particles and Fields II (3)
	G.S. Requirement (3)
	Electives (6)

Senior Year, First Semester (14-17 credit hours)

Phys 340	Heat, Thermodynamics and Pyrometry (3)
Phys 362	Atomic and Molecular Structure (3)
	G.S. Requirement (3)
	Electives (5-8)

Senior Year, Second Semester (15 credit hours)

Phys 171	Proseminar (1)
	G.S. Requirement (3)
	Electives (11)

The electives must include at least 14 hours of approved technical electives, including two of Physics 363, 364, 365, 366, 367, and 369.

The liberal number of electives provides flexibility in allowing the curriculum to be adapted to the needs and interests of the individual student. Those who are interested in an interdisciplinary field will choose some of their electives from other departments. To name a few possibilities, we mention: biophysics, chemical physics, geophysics, materials science, and physical oceanography. Students interested in preparing for work in these areas would probably elect some or all of the courses suggested below:

Biophysics:

Biol 21	Principles of Biology (3)
Biol 28	Genetics (3)
Biol 35	Microbiology (3)
Biol 320	Cell Physiology (3)
Chem 51	Organic Chemistry (3)
Chem 90 or 194	Physical Chemistry (3)
Chem 371	Elements of Biochemistry (3)
Phys 367	Introduction to Molecular Biophysics (3)
Phys 368	Molecular Biophysics (3)

Chemical Physics:

Chem 90	Physical Chemistry (3)
Chem 191	Physical Chemistry (3)
Chem 381	Radiation and Structure (3)
Phys 363	Physics of Solids (3)
Phys 369	Introduction to Quantum Mechanics (3)

Geophysics:

Geol 1	Principles of Geology (3)
Geol 23	Structural Geology (3)
Geol 301	Introduction to Geophysics (3)
Geol 304	Topics in Geophysics (3)
Phys 363	Physics of Solids (3)

Materials Science:

Met 91	Elements of Materials Science (3)
Met 218	Mechanical Behavior of Materials (3)
Met 315	Introduction to Physical Ceramics (3)
Met 316	Physical Properties of Materials (3)
Met 317	Imperfections in Crystals (3)
Phys 363	Physics of Solids (3)
Phys 369	Introduction to Quantum Mechanics (3)

Physical Oceanography:

Geol 363	Introduction to Oceanography (3)
Mech 323	Fluid Mechanics of the Ocean and Atmosphere (3)
Chem 334	Chemical Oceanography (3)
Phys 365	Physics of Fluids (3)
Phys 366	Ocean Physics (3)

Undergraduate Courses

11. Introductory Physics I (4) fall-spring
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. Mr. Folk.

12. Introductory Physics Laboratory I (1) fall-spring
A laboratory course to be taken concurrently with Physics 11. Experiments in mechanics, heat, and D.C. electrical circuits. One three-hour laboratory period per week.

13. General Physics (3) spring
Introduction to electricity and magnetism, waves, optics, and atomic physics, intended for students in the College of Arts and Science and the College of Business and Economics. Prerequisites: Phys. 11 and Math. 21, 31, or 41. Mr. Sands.

14. General Physics Laboratory (1) spring
A laboratory to accompany Physics 13. Prerequisites: Phys. 12; Phys. 13 preferably concurrently.

21. Introductory Physics II (4) fall-spring
A continuation of Physics 11. Electrostatics and magnetostatics; D.C. circuits; Maxwell's equations; waves; physical and geometrical optics; introduction to modern physics. Two lectures and two recitations per week. Prerequisites: Phys. 11, and Math. 23, 32, or 44 previously or concurrently. Mr. Radin.

22. Introductory Physics Laboratory II (1) fall-spring
A laboratory course to be taken concurrently with Physics 21. One three-hour laboratory period per week. Prerequisites: Phys. 12; Phys. 21, preferably concurrently.

31. Introduction to Quantum Mechanics (3) spring
Experimental basis and historical development of quantum mechanics; the Schrodinger equation; one-dimensional problems; angular momentum and the hydrogen atom; many-electron systems; spectra; selected applications. Three lectures per week. Prerequisites: Phys. 13 or 21, and Math. 205, previously or concurrently.

32. Modern Physics Laboratory (1)
Laboratory experiments dealing with quantum physics, and illustrative of material covered in Physics. 31. One three-hour laboratory period per week. Prerequisite: Phys. 21.

42. Physics for Poets (3) spring
The course designed for the nontechnical student. Topics are selected from the seventeenth- and twentieth-century revolutions in physics which produced mechanics, relativity, and quantum mechanics. These subjects have had profound and far-reaching effects on our society and on our philosophical outlook. High school physics is not assumed. Two recitation periods and one laboratory period per week. No prerequisites. Mr. Radin.

90. Electrical Phenomena (1) spring
Laboratory studies of elementary electric and magnetic effects. Elementary laboratory techniques. Prerequisite: Phys. 21, 22 or 13, 14.

171. Physics Proseminar (1) spring
Discussion of current problems in physics. Intended for seniors majoring in the field.

191. Laboratory Techniques (2) fall
Thermometric, calorimetric and vacuum techniques. Advanced electrical measurements. Prerequisite: Phys. 21, 22 or 13, 14.

192. Advanced Physics Laboratory (2-3) fall
Laboratory experiments in modern physics designed to introduce students to measuring techniques and phenomena of current interest. Work is of a project nature, and students placed largely on their own initiative. Intended for seniors majoring in the field.

193. Advanced Physics Laboratory (1-2) spring
Continuation of Phys. 192. Intended for seniors majoring in the field.

For Advanced Undergraduates and Graduates

212. Electricity and Magnetism I (3) fall
Electrostatics, magnetostatics, and electromagnetic induction. Prerequisites: Phys. 21 or 13; and Math. 205 previously or concurrently. Mr. Borse.

213. Electricity and Magnetism II (3) spring
Maxwell's equations; electromagnetic waves with applications to optics. Prerequisite: Phys. 212. Mr. McLennan.

215. Particles and Fields I (3) fall
Aims and fundamental concepts of theoretical physics; foundations of mechanics of mass points, systems of particles, and continuous media; waves; fields; conservation laws. Prerequisites: Math. 205, Phys. 21, or Phys. 13, previously or concurrently. Mr. Smith.

216. Particles and Fields II (3) spring
Generalized coordinates; variational methods in theoretical physics; the Lagrangian and Hamiltonian; basic concepts of the special theory of relativity; survey of the general theory of relativity. Prerequisite: Phys. 215. Mr. Shaffer.

254. Optics Laboratory (2) spring
Optical instruments and techniques. Examination of phenomena, of measuring procedures, and of light sources and recording devices. Prerequisite: Phys. 21 or 13.

281. Basic Physics I (3) summer
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.

282. Basic Physics II (3) summer
Continuation of Phys. 281.

300. Apprentice Teaching in Physics (1-3)

340. Thermal Physics (3) fall
Basic principles of thermodynamics, kinetic theory, and statistical mechanics, with emphasis on physical systems. Prerequisites: Phys. 13 or 21, and Math. 23, 32, or 44. Mr. Shaffer.

352. Modern Optics (3)
Paraxial optics, wave and vectorial theory of light, coherence and interference, diffraction, crystal optics, and lasers. Prerequisites: Math. 23, and Phys. 21 or 13. Mr. Bergmann.

362. Atomic and Molecular Structure (3) fall
Structure of atoms and molecules, especially as related to their spectra. Prerequisite: Phys. 31 or Chem. 191. Mr. VanSciver.

363. Physics of Solids (3) spring
Introduction to the theory of solids with particular reference to the physics of metals Prerequisite: Phys. 31 or Met. 316 or Chem. 191. Mr. Feigl.

364. Nuclear Physics (3) spring
Nuclear models and properties of nuclei. Interaction of nuclear radiation with matter and applications. Radioactive decay; phenomenology and theory. Radiation and particle detectors. Nuclear reactions. High energy physics. Accelerators. Practical nuclear physics applications. Prerequisites: Phys. 31 and Math. 205. Mr. Kanofsky.

365. Physics of Fluids (3) fall
Concepts of fluid dynamics; continuum and molecular approaches; waves, shocks and nozzle flows; nature of turbulence; experimental methods of study. Prerequisites: Phys. 212 or E.E. 231, and Phys. 340 or M.E. 104 or equivalent previously or concurrently. Mr. Emrich.

366. Ocean Physics (3)
Underwater sound and optics, thermodynamics of the oceans, other topics in physical oceanography such as currents, tides, and waves. Prerequisites: Math. 205 and Phys. 21 or 13. Mr. VanSciver.

367. Introduction to Molecular Biophysics (3) fall
A development of the molecular basis of life in terms of physical principles. Topics include molecular biology of the gene, energy flow as an organizing factor in biology, intra- and inter-molecular interactions, and the determination of macromolecular structure and function. Prerequisite: Phys. 13 or 21. Mr. Benson.

368. Molecular Biophysics (3) spring
Further topics in molecular biophysics including the problems of membrane structure and function, the action of radiation on cells and the structure of cell water. Techniques discussed will include ultracentrifugation, electron spin resonance, nuclear magnetic resonance, ultraviolet and infrared spectroscopy. Prerequisites: Phys. 367 or consent of chairman. Mr. Sands.

369. Introduction to Quantum Mechanics (3) fall
Principles of quantum mechanics; applications to atoms and molecules. Prerequisites: Phys. 31, 216, Math. 205. Mr. Bergmann.

372. Special Topics in Physics (1-3)
Special topics in physics not sufficiently covered in the general courses. Lecture and recitations or conferences.

For Graduates

The department of physics has concentrated its research activities within several fields of physics, with the consequence that a number of projects are available in each area. Current departmental research activities include the following:

Solid State Physics (Experimental). Optical properties of insulators, defects in insulators, electron paramagnetic resonance, properties of thin films.

Solid State Physics (Theoretical). Energy band calculations in insulators, excited states and lifetimes of defects, properties of impurities in insulators.

Molecular Biophysics. Magnetic resonance studies of nucleic acid derivatives.

Ocean Physics. Optical absorption and luminescence of organic and inorganic materials in sea water and ice.

Plasma Spectroscopy. Collisional and collisionless phenomena of very dense plasmas.

Nuclear Theory. The few nucleon problem, nuclear structure theory.

Physics of Fluids. Transition from laminar to turbulent flow in boundary layers, microscopic fluctuations in a flow, shock-induced reactions in gases, energy transfers, relaxation times, lifetimes, and phase transitions at liquid-vapor interfaces.

Statistical Physics. Kinetic theory, transport in plasmas with strong magnetic fields, statistical basis of hydrodynamics, non-linear processes.

Elementary Particles (Experimental). Extensive air shower studies and high energy multiple particle production at the AGS.

Elementary Particles (Theoretical). Properties of leptons, the vector boson, methods for handling unrenormalized field theories, electromagnetic interactions.

Laser Physics. Construction of gas lasers and studies of their characteristics; use of gas lasers in determination of oscillator strength and atomic parameters; mode structure; holography.

Candidates for advanced degrees normally will have completed, before beginning their graduate studies, the requirements for a baccalaureate degree with a major in physics, including advanced mathematics beyond differential and integral calculus. Students lacking the equivalent of this preparation will make up deficiencies in addition to taking the specified work for the degree sought.

Doctoral candidates may be required by their thesis committee to demonstrate a reading knowledge of one language, usually chosen from French, German or Russian. Some graduate work in mathematics is usually required; and certain advanced courses in other fields, notably mechanics, metallurgy, and materials science, 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 groups or their equivalent.

Special departmental facilities for teaching and research include six shock tubes with advanced instrumentation; optical and cryogenic equipment for solid state studies; magnetic resonance equipment. Facilities of the Materials Research Center are available, including crystal preparation equipment, electron microscope facilities, and light scattering equipment. Extensive use is made for both teaching and research of the Computing Center, which includes a CDC 6400 computer. The new Sherman Fairchild Laboratory for Solid State Studies, to be opened in 1976, will be the hub for solid-state activity on campus. It will house a 3 Mev. Van de Graaff accelerator and other research facilities.

Faculty from the physics department participate in the interdisciplinary M.S. and Ph.D. programs in molecular biology.

Graduate Courses

420. Theoretical Physics (3) fall
This and the three courses, Phys. 421, 422 and 423, cover the classical theory of particles and fields. Phys. 420 includes the variational methods of classical mechanics, methods of Hamilton and Lagrange, canonical transformations, Hamilton-Jacobi theory. Mr. Jones.

421. Theoretical Physics (3) spring
Theory of elasticity; fluid dynamics; tensor analysis; electrostatics and magnetostatics. Prerequisite: Phys. 420. Mr. Kim.

422. Advanced Theoretical Physics (3) fall
Electromagnetic radiation; dynamics of charged particles; multipole fields; special theory of relativity and covariant formulation of electrodynamics. Prerequisite: Phys. 421. Mr. Fowler.

423. Advanced Theoretical Physics (3) spring, alt. yrs.
Electrodynamics in anisotropic media; physical optics; theory of diffraction and application to holography; applications of electrodynamics in various fields of physics. Prerequisite: Phys. 422. Mr. Bergmann.

424. Quantum Mechanics (3) spring
General principles of quantum theory; approximation methods; spectra; symmetry laws; theory of scattering. Prerequisite: Phys. 369 or equivalent. Mr. Borse.

425. Quantum Mechanics (3) fall, alt. yrs.
A continuation of Phys. 424. Relativistic quantum theory of the electron; theory of radiation. Mr. Shaffer.

428. Methods of Mathematical Physics (3) fall
The equations of theoretical physics and the methods of their solution. Mr. Folk.

429. Methods of Mathematical Physics (3) spring
Continuation of Phys. 428. Mr. Folk.

431. Theory of Solids (3) fall
Advanced topics in the theory of the electronic structure of solids. Many-electron theory. Theory of transport phenomena. Magnetic properties, optical properties. Superconductivity. Point imperfections. Desirable preparation: Phys. 363 and Phys. 424. Mr. Fowler.

434. Solids and Radiation (3) alt. yrs.
Phenomena in solids resulting from interaction with electromagnetic radiation or charged particles. Current theories of energy adsorption, transport, and emission. Prerequisite: Phys. 363 or equivalent.

442. Statistical Mechanics (3) fall
General principles of statistical mechanics with application to thermodynamics and the equilibrium properties of matter. Prerequisites: Phys. 340 and 369. Mr. Kim.

443. Statistical Mechanics (3) alt. yrs.
A continuation of Phys. 442. Applications of kinetic theory and statistical mechanics to non-equilibrium processes; non-equilibrium thermodynamics. Prerequisite: Phys. 442. Mr. McLennan.

462. Theories of Elementary Particle Interactions (3) alt. yrs.
Relativistic quantum theory with applications to the strong, electromagnetic and weak interactions of elementary particles. Prerequisite: Phys. 425. Mr. Shaffer.

465. Nuclear and Elementary Particle Physics (3) spring
Nuclear structure and phenomena; interactions among elementary particles and methods of studying them. Mr. Kanofsky.

467. Nuclear Theory (3) spring, alt. yrs.
Theory of low energy nuclear phenomena within the framework of non-relativistic quantum mechanics. Mr. Borse.

471. (Mech. 411) Continuum Mechanics (1-3) fall
An introduction will be given to the non-linear continuum theories of the mechanics of solids and fluids. This will include a discussion of the mechanical and thermodynamic bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of the nonlinear theories to specific problems will be given. Mr. Rivlin.

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.

475. Seminar in Modern Physics (3)
Discussion of important advances in theoretical physics.

491. Research (3)
Research problems in experimental or theoretical physics.

492. Research (3)
Continuation of Phys. 491. May be repeated for credit.

Psychology

Professors

Arthur L. Brody, Ph.D., *Chairman*
Joseph M. Brozek. Ph.D.

Associate Professors

William Newman, Ph.D.
Martin L. Richter, Ph.D.
George K. Shortess, Ph.D.

Assistant Professors

Edwin J. Kay, Ph.D.
Roger C. Loeb, Ph.D.

Instructors

Hilliard G. Foster, Jr., M.S.
Leslie Horst, B.A.

Adjunct Professors

Herbert Rubenstein, Ph.D.
John B. Siegfried, Ph.D.
Mervin P. Smolinsky, Ph.D.

There are two major programs available in psychology. The bachelor of arts program is in the liberal arts tradition with the student free to include courses from a wide variety of academic disciplines and with maximum freedom of course selection in psychology. With a judicious selection of courses, students can prepare themselves for graduate study in clinical psychology, developmental psychology, social psychology, or personality, or for careers in areas for which psychology is a desirable and relevant major, e.g., law, social work, nursing, or special education.

The B.S. program stresses preparation in mathematics and science with an emphasis on experimental psychology. This program is intended for the student who plans on graduate study in experimental psychology, medicine or dentistry.

The Bachelor of Arts Major

Required Major Courses

Psychology: 24 semester hours with at least 12 semester hours in courses numbered 100 or higher.

Additional Required Courses

College of Arts and Science distribution requirements. Elective courses to bring semester hour total to 120.

Recommended Courses

Strongly recommended courses for students preparing for graduate study in clinical psychology, developmental psychology, social psychology, or personality.

Psych 3	Psychology as a Natural Science (3) or
Psych 4	Psychology as a Social Science (3)
Psych 9	Statistical Analysis (3)
Psych 111	General Experimental Psychology (4)
Psych 161	Independent Research (1-3)

plus a selection from the following recommended courses:

Psych 107	Child Psychology (3)
Psych 162	Psychological Field Work (3)
Psych 205	Abnormal Psychology (3)
Psych 311	History of Modern Psychology (3)
Psych 353	Personality Theory (3)
Psych 354	Personality Assessment (3)
Psych 371	Learning (3)
Psych 373	Sensory Processes (3)
Psych 375	Physiological Psychology (3)
SR 7	Individual and Society (3) or
SR 121	Social Psychology of Small Groups (3)
Math 41	BMSS Calculus (3)
Biol 21	Principles of Biology (3) or
Biol 28	Genetics (3)

The Bachelor of Science Major

Required Major Courses

Psych 3	Psychology as a Natural Science (3)
Psych 4	Psychology as a Social Science (3)
Psych 9	Statistical Analysis (3)
Psych 51	Elementary Quantitative Psychology (3)
Psych 111	General Experimental Psychology (3)
Psych 311	History of Modern Psychology (3)
Psych 371, 372	Learning and Laboratory (4)
Psych 373, 374	Sensory Processes and Laboratory (4)
Psych 375, 376	Physiological Psychology and Laboratory (4)

Additional Required Courses

Engl 1	Composition and Literature (3)
Engl 2, 10, 14, or 16	Composition and Literature (3)
Math 21, 22, 23	Analytic Geometry and Calculus (12) or
Math 31, 32	Calculus (8) or
Math 41, 42, 43, 44	BMSS Calculus, Probability, Linear Algebra, Calculus (12)
Biol 21, 22	Principles of Biology and Laboratory (4)
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Phys 11, 12	Introductory Physics I and Laboratory (5)
Phil	selection of a philosophy of science course (3)

plus 12 semester hours selected from the following:

Math 105	Computer Programming (3)
Math 205	Linear Methods (3)
Math 219	Principles of Analysis I (3)
Math 220	Principles of Analysis II (3)
Math 231	Statistical Inference (3)
Math 309	Theory of Probability (3)
Math 310	Probability and its Applications (3)
Math 334	Mathematical Statistics (3)
Math 362	Computer Languages (3)
Biol 28	Genetics (3)
Biol 306	Ecology (3)
Biol (Geol) 317	Evolution (3)
Biol 320	Physiology (3)
Biol 324	Animal Behavior (3)
Chem 51	Organic Chemistry (3)
Chem 52	Organic Chemistry (3)
Chem (Biol) 371	Elements of Biochemistry (3)
Chem (Biol) 372	Advanced Biochemistry (3)
Phys 21, 22	Introductory Physics II and Laboratory (5)
IS 201	Computers and Language (3)
IS 202	Computers and Society (3)
IS 302 (Psych 320)	Psycholinguistics (3)
IS 320 (Psych 308)	Information Processing: Human and Machine (3)
IS 361	Theory of Formal Grammars (3)

or other courses with the approval of the department chairman. (It is recommended that these 12 semester hours be

concentrated in an area, e.g., mathematics, probability and statistics, biology, biochemistry, computer science.)

plus forty-two semester hours of electives (46 semester hours if Math. 31 and 32 are taken), of which at least thirty semester hours are to be selected from the humanities and social sciences.

The Psychology Minor

The psychology minor consists of fifteen credit hours in psychology chosen by the student together with a faculty advisor from the psychology department.

Undergraduate Courses

Note: As with other course listings, the code initials on the first line of each entry indicate the course's distribution-level rating. The next entry, NS or SS, applies only to psychology courses and refers to Natural Science or Social Science distribution requirements. Some listings also state the semester in which the course is customarily offered.

3. Psychology As a Natural Science (3) P NS fall
Introduction to psychology as a science of behavior. Emphasis on principles of sensation, perception, maturation, learning, motivation, emotion and physiological bases of behavior. Messrs. Foster and Richter.

4. Psychology As a Social Science (3) P SS spring
Introduction to psychology as a science of behavior. Emphasis on principles of human development, intelligence, abilities, perception, motivation and learning, personality theory and social psychology. Ms. Horst and Mr. Newman.

9. Statistical Analysis (3) P NS spring
An integrated presentation of the basic methods of evaluating data in psychological research. Mr. Kay.

51. Elementary Quantitative Psychology (3) P NS fall
Quantitative analysis of behavior, including perception, choice and preference, conditioning, memory, and problem-solving. Messrs. Kay and Richter.

107. Child Psychology (3) SS fall
Theories and data concerning the development of the human organism from fetus to adolescent. Emphasis is placed on the methods and techniques employed. Prerequisite: Psych. 3 or 4. Mr. Loeb.

108. Adolescent and Adult Psychology (3) SS alt. yrs.
Descriptions and explanations of the developmental process from adolescence to death. Stresses of adolescence, changes during adulthood, and ways of dealing with old age and death. Prerequisite: Psych. 3 or 4. Mr. Loeb.

111. General Experimental Psychology (4) NS spring
A survey of basic data and research methods in experimental psychology with emphasis on the areas of learning and psychophysics; laboratory exercises and an independent research project. Prerequisite: Psych. 3 or 4. Mr. Richter.

121. Encountering Self and Others (3) SS fall-spring
An experientially oriented course to facilitate personal growth and develop a fuller awareness of personal functioning and interpersonal perception and communication. Prerequisite: consent of department chairman. Ms. Horst and Mr. Newman.

131. Psychology of Women (3) SS fall
Perspectives on the psychology of women, including the biological, sociological, and psychological, with reference to personal experience where appropriate. Prerequisites: Psych. 3 or 4 or an introductory social relations course, and consent of department chairman. Ms. Horst.

160. Independent Study (1-3) NS SS fall-spring
Readings on topics selected in consultation with a staff member. Prerequisites: Psych. 3 or 4 and consent of department chairman. May be repeated for credit.

161. Independent Research (1-3) NS SS fall-spring
Research in areas selected in consultation with a staff member. Prerequisites: Psych. 3 or 4, 111, and consent of department chairman. May be repeated for credit.

162. Psychological Field Work (3) SS fall-spring
Work-study practice including supervised experience in one of several local agencies. Development of familiarity with the operations of the agency and working with individual patients or students. Prerequisites: Psych. 3 or 4 and consent of department chairman. May be repeated for credit. Mr. Loeb.

For Advanced Undergraduates and Graduates

201. Industrial Psychology (3) SS spring
The application of psychological concepts and methods to business and industry. Includes personnel selection, placement and training; studies of work environment, motivation and morale; consumer research and advertising. Prerequisite: Psych. 3 or 4.

205. Abnormal Psychology (3) SS fall
The patterns, causes, and treatment of various forms of abnormal behavior. Supplemented by sessions at the Allentown State Hospital. Prerequisites: Psych. 3 or 4, and three additional hours of psychology or consent of department chairman. Mr. Loeb.

211. Insanity: Psychological and Legal Views (3) SS fall
Problems with the concept of insanity, its use and misuse; commitment procedures, incompetency, and the insanity defense; the right to treatment and to refuse treatment; the right to be different and the dangers of a therapeutic society. Mr. Brody.

221. Psychophysiology of Motivation (3) NS fall
Neurological foundations of thirst, hunger, temperature regulation, reproduction, and maternal behavior. Prerequisite: Psych. 3. Mr. Foster.

300. Apprentice Teaching in Psychology (1-3) NS SS fall-spring

301. Psychological Principles in Systems Design (3) SS fall
Experimental psychology as applied to the optimal design of machines, tasks and environments, including a survey of human capacities, limitations and requirements in systems, traditional areas of engineering psychology in man-machine systems and considerations of man in social and environmental systems. Prerequisite: Psych. 3 or 4.

303. Mathematical Models in Psychology (3) NS fall
The application of mathematics in psychology, including models for psychophysics, learning acquisition curves, discrimination learning, concept formation and probability learning. Prerequisite: Psych. 111. Mr. Kay.

307. Perception-Cognition (3) NS fall
Processes by which sensory inputs are transformed, reduced, elaborated, stored, recovered and used. Contemporary theories of perception and memory, psycholinguistics, computer simulation of cognitive processes, information processing models, and concept learning and formation. Prerequisite: Psych. 3 or 4.

308. (I.S. 320) Information Processing: Human and Machine (3) NS alt. yrs.
Study of the identification, storage, retrieval, and use of auditory and visual inputs in decision-making contexts. Human and mechanical information processes, their similarities and differences. Mr. Rubenstein.

311. History of Modern Psychology (3) NS fall
History of psychology, with emphasis on the emergence and growth of scientific study of behavior. Includes the reading of primary sources and the autobiographies of the major contributors to the field. Prerequisite: Psych. 3 or 4. Mr. Brozek.

314. Psychobiology of Human Sexuality (3) NS spring
Structure and differentiation of male and female genitalia, brains, and endocrine systems; fertilization, birth control, and sex determination in offspring; techniques and stages in human arousal; disease and disorders of the genito-urinary system; and the biological and social bases of sexual deviancy. Prerequisites: Psych. 375 and 376 or Biol. 320 or 322, and consent of department chairman. Mr. Foster.

320. (I.S. 302) Psycholinguistics (3) SS spring
For course description, see I.S. 302. Mr. Rubenstein.

331. Humanistic Psychology (3) SS fall
The literature of and metaphors underlying the humanistic point of view in psychology. These "models of man" will be contrasted with models underlying other modes of psychological inquiry. Prerequisite: Psych. 3 or 4. Mr. Newman.

353. Personality Theory (3) SS fall
Review and critique of a number of theories of personality. Includes the process of developing knowledge and theory about people as well as the theoretical concepts themselves. Prerequisite: Psych. 3 or 4. Ms. Horst.

354. Personality Assessment (3) SS spring
Methods of describing and measuring personality. Observational techniques, interviews, self-report inventories, intelligence tests, and projective tests. Prerequisite: Psych. 3 or 4 and consent of chairman. Mr. Loeb.

371. Learning (3) NS spring
Principles of learning with emphasis on reinforcement, discrimination, motivation, verbal learning and memory. Critical evaluation of classical and contemporary theories of learning. Prerequisite: Psych. 3 or 4. Messrs. Brody and Richter.

372. Learning Laboratory (1) NS spring
Experimentation on the learning process utilizing animal and human subjects. Prerequisites: Psych. 111; Psych. 371, previously or concurrently. Messrs. Brody and Richter.

373. Sensory Processes (3) NS spring
Receptor processes of vision, audition, touch, taste and smell are considered with particular emphasis on problems of sensory intensity, sensory discrimination functions and perceptual processes. Quantitative methods are stressed. Prerequisite: Psych. 3 or 4. Mr. Shortess.

374. Sensory Processes Laboratory (1) NS spring
Laboratory exercises applying quantitative methods to the study of sensory processes. Prerequisites: Psych. 111; Psych. 373, previously or concurrently. Mr. Shortess.

375. Physiological Psychology (3) NS fall
The physiological basis of behavior, both human and animal. Particular emphasis is placed on the neural mechanisms involved. Prerequisites: Psych. 3 or 4; eight semester hours of physics, chemistry or biology. Messrs. Foster and Shortess.

376. Physiological Psychology Laboratory (1) NS fall
A survey of techniques in physiological psychology. Prerequisite: Psych. 375 previously or concurrently. Messrs. Foster and Shortess.

378. Psychochemistry (3) NS spring
Neurochemical, pharmacological, endocrinological, and nutritional changes effecting or accompanying emotional, motivational, or learned behavior. Prerequisites: Psych. 375 and 376, or Biol. 320 or 322, or consent of department chairman. Mr. Foster.

381. Psychological Testing (3)
Psychological tests of intelligence, achievement, and personality with emphasis on applications in educational situations. Principles of measurement and test construction stressed. Prerequisite: Psych. 3 or 4, or consent of department chairman. Open only to graduate students in the School of Education. Mr. Brody.

382. Child Psychology (3)
A systematic analysis of the critical periods of development from infancy through adolescence. Alternate theories and recent research will be stressed. Prerequisite: Psych. 3 or 4, or

consent of department chairman. Open only to graduate students in the School of Education. Mr. Loeb.

383. Personality (3)
Review and analysis of psychological concepts and data relevant to the development and functioning of personality. Comparison and critical examination of the major historical schools of personality theory. Prerequisite: Psych. 3 or 4, or consent of department chairman. Open only to graduate students in the School of Education. Mr. Smolinsky.

For Graduates

Graduate study in psychology at Lehigh University is designed to educate a limited number of students for careers in teaching and research. There is an emphasis on independent study and research. A student-faculty ratio of approximately two to one makes it possible for all students to establish a close working relationship with the faculty. Programs are available leading to the Ph.D. and D.A. (Doctor of Arts) degrees. Both programs are in general experimental psychology with the Ph.D. program emphasizing research and the D.A. program designed as preparation for a career in college teaching at two-year and four-year colleges. The D.A. program differs from the Ph.D. program in having a broader distribution of graduate courses, training in interpersonal awareness, an extensive research project dealing with problems of teaching and learning rather than a dissertation, and a supervised internship in college teaching.

The beginning student in both programs is required to take during his or her first year: Proseminar, an intensive one-year course covering topics in experimental psychology; Analysis and Design of Experiments, a one-year course in probability, statistics, and research methodology; Research, an apprentice program in which the student works with a faculty member on a current research project; College Teaching of Psychology, which includes consideration of problems of teaching and professional activity, and teaching practice; and two content courses selected by the student. An evaluation of each student is made at the end of the first year, based on examinations in Proseminar and Analysis and Design of Experiments, progress in research and performance in other courses. During the second year, the student chooses four content courses and completes a required master's thesis which may evolve from the apprentice research.

Following the first two years, the program is tailored to each student's special interests with the student selecting from a variety of psychology courses. A required outside minor consists of integrated course work offered by a department other than psychology, relevant to the specialization of the student. There are no foreign language requirements.

A general examination is administered to all candidates for a doctoral degree no later than the end of the third year. This is intended as an evaluation of the student's ability to organize, write and speak knowledgeably on the content, methodology, theory and current issues in experimental psychology. In addition, there is an oral final examination focusing on the Ph.D. dissertation or D.A. project.

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 aptitude tests and advanced test in experimental psychology should be returned to the Office of Admission not later than February 1 of the year of admission. Normally, new students are accepted for entrance into the program only for the fall semester. Financial support is available in the form of teaching and research assistantships, fellowships and scholarships. There are special fellowships for black students.

The minimum prerequisites for admission are one course in each of the following: general psychology, experimental psychology including a laboratory, and statistics, plus collateral courses in biology, mathematics, and the physical sciences. Additional course work, the equivalent of a major in psychology, is desirable but not necessary. Promising students with majors other than psychology, especially in the biological and physical sciences, mathematics, or engineering, are encouraged to apply.

401. Proseminar (3) fall
Intensive examination of the classic work and current issues in a variety of areas of experimental psychology.

402. Proseminar (3) spring
Continuation of Psych. 401.

411. Interpersonal Awareness (3)
Designed to improve awareness of personal functioning and to enhance interpersonal perception and communication. Application to problems of teaching and learning. Prerequisite: consent of department chairman. May be repeated for credit. Mr. Newman.

421. Analysis and Design of Experiments (3) fall
Set theory, probability theory, inferential statistics, parametric statistical tests with emphasis on the analysis of variance, trend analysis, regression analysis. Mr. Kay.

422. Analysis and Design of Experiments (3) spring
Continuation of Psych. 421. Prerequisite: Psych. 421. Mr. Kay.

434. Special Topics in Personality (3)
Selected topics in personality theory and research, including but not limited to personal change, ego psychology, and psychology of women. May be repeated for credit. Ms. Horst.

438. Special Topics in the History of Psychology (3)
Contemporary historiography of psychology; methods of historiography, with special reference to quantitative and archival research; roots of experimental psychology in experimental psychology; history of Russian and Soviet psychology; history of research on visual functions. May be repeated for credit. Mr. Brozek.

441. Communicating Psychological Concepts (3)
How to organize facts and ideas into broader meaningful units that are readily communicable. Includes media aids and the structured experience as a communication aid. Prerequisite: consent of department chairman. Mr. Newman.

448. (I.S. 402) Seminar in Psycholinguistics (3)
For course description, see I.S. 402. Mr. Rubenstein.

450. Special Topics in Mathematical Models and Statistics (3)
Selected topics in the application of mathematics to psychological theory and the application of statistics to psychological research. May be repeated for credit. Messrs. Brody, Kay and Richter.

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.

460. Special Study (1-3) fall-spring
Study of some special topic not covered in the regular course offerings. May be repeated for credit.

461. Research (1-3) fall-spring
Original research not connected with master's or doctoral thesis. May be repeated for credit.

463. College Teaching of Psychology (1-3) fall-spring
Consideration of problems in the preparation and presentation of college courses in psychology; ancillary problems associated with the profession of psychology; practice in teaching. May be repeated for credit. Mr. Newman.

465. Teaching Internship (3-6) fall-spring
The preparation, teaching and grading of one or two undergraduate courses with appropriate supervision by Lehigh faculty. Observation and evaluation of the intern via classroom visits and videotapes. May be repeated for credit.

472. Special Topics in Physiological Psychology (3)
Selected topics from sensory psychophysiology, drive, short-term memory mechanisms, bioelectrics, etc. May be repeated for credit. Messrs. Foster and Shortess.

474. Special Topics in Developmental Psychology (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. Mr. Loeb.

476. Special Topics in Cognition (3)
Selected topics in cognitive processes including thinking, imagery, daydreaming, states of consciousness, creativity, and psychophysiological correlates of these processes. May be repeated for credit.

Religion Studies

Professor

A. Roy Eckardt, Ph.D., *Chairman*

Assistant Professor

Hubert L. Flesher, M.A.

Instructor

Patricia L. Basu, M.A.

Lecturer

Alice L. Eckardt, M.A.

As an intrinsic dimension of culture, religion exerts abiding influence upon human thought, affect, and behavior. This fact furnishes the rationale for the study of religion at Lehigh. The department of religion studies is committed to forms of intellectuality identical with those pursued in other humanistic and scientific disciplines. The primary purpose in the department is to foster and complete the individual student's liberal education. Secondarily, the scholarly analysis of religion comprises one foundation for a mature personal and social faith.

Courses afford a comprehensive understanding of the world's major religious traditions and their contributions to human culture. The curriculum extends through the methodology of and introduction to religion study, the history of religions in East and West, biblical studies, the place of personal and social religion within a secular culture, influential theological movements and issues, and the relating of religion and theology to contemporary moral, social, and aesthetic questions.

The study of religion in inherently interdisciplinary. Students who major in religion studies are enabled to concentrate upon one or more of the above sub-fields. The major is preparatory to a number of professions and vocations, including the law, medicine, government service, teaching, journalism and business.

Required Preliminary Courses

To enter the department, a student takes one of the following: R.S. 15, 51, 52, 61 or 62.

Required Major Courses

A minimum of ten additional courses in Religion Studies are selected in consultation with the department chairman.

Religion studies majors are encouraged to pursue collateral work in such fields as American Studies, classics, economics, English, fine arts, government, history, international relations,

modern foreign languages, philosophy, psychology and social relations. Students planning to pursue graduate work are advised to study a foreign language or foreign languages appropriate to their area of concentration.

Minor in Religion Studies

Fifteen credit hours are chosen in consultation with the department chairman.

Recommended Freshman Distribution Courses

The normal possibilities include R.S. 15, 51, 52, 61 and 62. In counsel with their advisors, freshmen may wish to petition for one or another 100-level course.

Recommended Upperclass Distribution Courses

Students are urged to seek the counsel of their advisors and of the chairman of the department in choosing courses at the 100 level and above.

Note on Languages

With sufficient student demand, the department will offer for credit instruction in Biblical Hebrew and readings in the Greek New Testament.

Undergraduate Courses

15. Methods and Issues (3) P fall-spring
Introduction to the study of religions. Emphasis upon alternative methods of analyzing religious phenomena and upon such major issues as time and history, "natural" and induced mystical experience, and good and evil. Not open to students who have had R.S. 61.

51. Faiths of the Orient (3) P fall
The rise, development, and teachings of Hinduism, types of Buddhism, and several lesser-known religions of India.

52. Faiths of the West (3) P spring
The rise, development, and teachings of Judaism, Christianity, and Islam.

61. Issues of Faith (3) P fall
The problem of achieving a viable personal faith. Study of such persistent issues as: Is God real? Is there hope? Does faith conflict with reason and science? How are we to decide between competing faith-claims? What is man? Why do people suffer? What is man's destiny? Not open to students who have had R.S. 15.

62. Religion and Modern Society (3) P spring
The relating of religious principles and theological understanding to a comprehension and resolution of pressing moral and social issues of today: sex, marriage, and intermarriage; revolution, the law, and civil rights; racism and religious prejudice; bio-medical ethics; and problems in ecology.

65. (Hist. 65). Mediterranean Civilizations, 500-1200 (3) fall
Intellectual, political, and institutional aspects of Islamic, Christian, and Jewish civilizations in the Mediterranean basin. Emphasis upon the impact of Islam on the peoples of that region.

66. (Hist. 66). Mediterranean Civilizations, 1200-1700 (3) spring
Rise and decline of the Ottoman, Venetian and Spanish empires, and their struggles for regional hegemony.

111. Biblical Studies I (3) fall
Theological examination of a major portion of the Hebrew Scriptures, with emphasis upon literary, historical, and critical problems. The Near Eastern context of Hebraic religious development; the Exodus tradition and the Patriarchal Period; the conquest of the land; the development and dissolution of the monarchy; beginnings of the prophetic movement.

112. Biblical Studies II (3) spring
Theological examination of the later Hebrew Scriptures and the Intertestamental Period. The prophetic movement; the Exile and return; the Temple and its culture; the Wisdom Literature; the rise of apocalyptic thought; the Maccabees and the Roman conquest; the Dead Sea Scrolls; Palestine and Judaism in Jesus' time; the sectarian movement of John the Baptist and Jesus as represented in the New Testament.

113. Biblical Studies III (3) fall
Study of early Christianity, with emphasis upon New Testament and early Apostolic writings. The Synoptic Gospels; the Fourth Gospel; Paul's writings; the later Epistles; the Apostolic Fathers; the development of Gnosticism; parallel Hellenistic religions; newly discovered secret gospels from the second century.

151. The Jewish-Christian Encounter (3) fall
Analysis of relations between the Jewish community and the Christian church in history and the present. Stress upon moral issues such as antisemitism and upon doctrinal similarities and differences between Judaism and Christianity. Religious and sociopolitical aspects of the reestablishment of the State of Israel.

152. (Hist. 152). American Religions (3) fall
The historical development of major religious groups in this country from colonial times to the present. Their place in social and political life. Emphasis upon the uniqueness of American religious pluralism and of the church-state relationship.

154. (Hist. 154). The Holocaust: History and Meaning (3) spring
The Nazi Holocaust in its historical, political, and religious setting. Emphasis upon the moral, cultural, and theological issues raised by the Holocaust.

161. Current Issues in Theology I (3) fall
Major twentieth-century movements in Protestant theology, understood as responses to the problems of modern times.

Study of such theologians as Karl Barth, Dietrich Bonhoeffer, Rudolf Bultmann, James H. Cone, Reinhold Niebuhr, Richard Niebuhr, and Ian T. Ramsey. Emphases include demythologizing, "the death of God," liberalism versus conservatism, new trends in hermeneutics, and the ecumenical movement.

162. Current Issues in Theology II (3) spring
Major twentieth-century movements in Roman Catholic and Jewish theology, understood as responses to the problems of modern times. Study of such theologians as Martin Buber, Abraham Heschel, Hans Kung, Jacques Maritain, and Karl Rahner. Current issues such as Vatican Council II and its aftermath, and "radical Judaism."

For Advanced Undergraduates and Graduates

261. Seminar in World Religions (3) fall-spring
In-depth study of selected topics within Hinduism, Buddhism, African religions, or other world religions.

272. Religion and the Arts (3) spring
Examination of religious themes in literature, film, and painting, with materials drawn from both the Eastern and the Western traditions.

300. Apprentice Teaching in Religion Studies (1-3) fall-spring

302. Seminar: Technology-Science-Theology (3) spring
The understanding and assessment of our technological society through study of such contemporary thinkers as Ian Barbour, Harvey Cox, Jacques Ellul, Pierre Teilhard de Chardin, and Paul Tillich.

313. (I.R. 313) Seminar in Religion and International Affairs (3) spring
From the standpoint of theological understandings of man's nature and of human collective life, an assessment of the nation-state, of the role of power in international affairs, of national sovereignty and internationalism, and of war, pacifism, and alternative methods of conflict-resolution.

371. Readings in Religion (3) fall
Selected scholarship in religion, particularly for students with special competence or interest in an area not covered by rostered courses. Prerequisite: consent of department chairman.

372. Readings in Religion (3) spring
Continuation of Religion Studies 371. Prerequisite: consent of department chairman.

Social Relations

Professor

Robert C. Williamson, Ph.D., *Chairman*
Linton C. Freeman, Ph.D., *Lucy G. Moses Distinguished Professor*
Morris H. Sunshine, Ph.D.

Associate Professors

Roy C. Herrenkohl, Jr., Ph.D.
James R. McIntosh, Ph.D.

Assistant Professors

Barbara Brown Frankel, Ph.D.
Robert E. Rosenwein, Ph.D.

There are three disciplines combined in the department of social relations: social psychology, sociology, and anthropology-behavioral sciences.

With rapid expansion of the significance of the social sciences in contemporary society, these three fields provide useful background not only for graduate work in the disciplines, but also for careers as diverse as law, government service, community relations, or the ministry. As an interdisciplinary department, social relations provides a unique opportunity for the student to maintain a broad scope of interests within the context of the major program.

Requirements for the Major

SR 211, 212 (6)

At least one of the following:
SR 386, 391, 393, 395 or 399(3)

Four at the 300 level (12)

total required hours (24)

Requirements for the Minor

15 hours including SR 211-212

Undergraduate Courses

5. The Social System (3) P
Analysis of social organization emphasizing structure, function, stability and change.

7. The Individual in Society (3) P
Study of interpersonal behavior, groups, and social environment.

9. The Anthropological Enterprise (3) P
Comparing and contrasting different social and cultural ver-

sions of the world. What anthropologists do and how they think about what they do.

41. Human Sexuality (3) P
Analysis of the socialization of sex roles and the life cycle, premarital and marital sex behavior, human reproduction and its control. Some attention to deviant sex roles.

51. Visual Sociology (3) P
Introduction to the use of the still camera as a tool for creating important social and sociological images. Development of the photo essay as a sociological reporting technique. Mr. Freeman.

52. Social Sciences and the Arts (3) P
Contributions of the social sciences to the understanding of aesthetic processes and products; focus on one or more media and/or a specific class of aesthetic objects. Messrs. Freeman and Rosenwein.

65. Contemporary Social Problems (3) P
Studies of major problems facing contemporary society. May be repeated for credit by permission of department chairman. Mr. McIntosh.

75. Minority Groups (3) P
Study of racial and ethnic intergroup relations.

85. Sociology of Politics (3) PU
Organization and development of political action structures. Analysis of ideology, stratification, leadership, and patterns of participation. Mr. Sunshine.

111. Social Psychology of Education (3)
An examination of the manner in which teaching and learning are influenced by interpersonal, group and institutional factors. The influence of family dynamics, peer-group pressures, teacher-expectations and social status on the individual's educational adjustment.

121. Social Psychology of Small Groups (3)
Study of interpersonal behavior in groups. Survey of relevant theories and empirical research. Mr. Rosenwein.

131. Science, Technology, and Society (3)
Relationships of science and technology to social life. May be repeated for credit by permission of department chairman.

141. Social Deviance (3)
Analyses of deviant social systems, supporting factors maintaining them, and societal responses to deviant roles and collectivities. Mr. McIntosh.

151. Utopias and Alternative Communities (3)
The search for new forms of community placed in historical and theoretical perspective. Mrs. Frankel.

161. Sociology of Occupations (3)
Analysis of occupational choice, recruitment, training, and socialization. Attention to the questions of the occupational-professional continuum, the work setting, alienation, the relation of careers to various social organizations, the life cycle and demographic trends. Mr. Williamson.

171. Computer Applications in Social Relations (3)
Practicum in a topic such as secondary data analysis, information retrieval, simulation, or visual display for applications in social relations. Topic announced in advance. Prerequisite: knowledge of a programming language. Mr. Freeman.

211. Integrated Study of Social Relations (3) fall
Theory and methodology in analyses of social relations. Use of contemporary journals and other materials providing an introduction to requisite skills in anthropology, sociology, and social psychology.

212. Integrated Study of Social Relations (3) spring
Continuation of S.R. 211. Prerequisite: S.R. 211.

307. Attitudes and Social Influence (3)
An examination of the concept of attitude in social psychology and the determinants of attitude-change. Attention to problems and issues in persuasive communication, propaganda, brainwashing, conformity, and other social processes. Prerequisite: S.R. 211 or 212 or consent of department chairman.

308. (Psych. 322). Seminar in Social Psychology (3)
Intensive consideration of selected topics in current theory and research in social psychology. The subject matter will vary from semester to semester, and will include 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. Prerequisite: S.R. 211 or 212 or consent of department chairman. May be repeated for credit by permission of chairman.

309. Socialization Through the Life Span (3)
An examination of interpersonal influences on human development from birth through aging. Consideration of social influences on the development of the ability to communicate, the learning of social roles, the development of socially oriented motivation, personality dynamics, and the impact of societal pressures on the processes of maturing and aging. Prerequisite: S.R. 211 or 212, or consent of department chairman.

311. Social Ecology (3) fall
Relationships between people and artificial environment. Architectural design, social organization, personal awareness of environment, and human needs for privacy, personal territory, or interpersonal space. Mr. Herrenkohl.

312. Interpersonal Behavior in Small Groups (3)
Intensive consideration of theoretical and methodological issues in the analysis of the development of small groups. Prerequisite: S.R. 211-212 or consent of department chairman. Mr. Rosenwein.

320. Urban Ethnology (3)
Urban subcultures of several continents and their relations to "mainstream" cultures; consideration of various methods appropriate to their scientific investigation. Mrs. Frankel.

321. (Hist. 321) Social Class and Mobility in American History (3)
The distribution of wealth, concepts of class and social democracy, life styles and values of different social and economic groups, and opportunities for mobility; colonial times to the present.

336. Symbolic Anthropology (3)
Study of how human experience is mediated through the use of symbols; religious, linguistic, and artistic symbol systems in cross-cultural perspective. Prerequisite: S.R. 211-212 or consent of department chairman. Mrs. Frankel.

337. Anthropological Theory (3)
Major social-scientific synthises used by anthropologists in the field of anthropology and how these do or do not qualify as "theories." Prerequisite: S.R. 211-212 or consent of department chairman. Mrs. Frankel.

339. Seminar in Anthropology (3)
Intensive consideration of selected topics in contemporary or past research in cultural anthropology. The subject matter will vary from semester to semester. May be repeated for credit. Prerequisite: S.R. 211-212 or consent of department chairman.

361. Social Conflict (3)
An examination of theory and research on interpersonal, inter-group and international conflict and conflict resolution. Consideration of the characteristics of individuals and of the dynamics of groups which predispose them to conflict or enable them to avoid or resolve conflict. Mr. Sunshine.

364. The Family (3) spring
A sociological study of man's basic institution. Includes: an analysis of historical backgrounds, interactions within the family, relation to other groups and institutions, problems of family disorganization, legal aspects of marriage and divorce, family adjustment, the family in a changing society. Mr. Williamson.

367. Change and Conflict in Latin America (3) fall
Introduction to the changing societies of Latin America including contrasts between urban and rural subcultures. Analysis of ethnic groupings and social institutions, especially family, school, and church. Mr. Williamson.

368. The Urban Community (3) spring
A study of urban communities in the world and the United States. A history of the city, ecological and demographic patterns and growth, institutional organization, status systems, suburban development, resources and problems, future development and planning. Prerequisite: six credit hours in social relations or consent of department chairman. Mr. McIntosh.

369. Social Disorganization (3)
Social disorganization in contemporary society, with emphasis on the concepts of anomie and alienation. Evaluation of various theories of social disorganization. Prerequisite: six credit hours in social relations or consent of department chairman.

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 anti-social activity; and evaluation of institutional controls and treatment of the problem.

371. Special Topics in Social Relations (1-3)
An opportunity for advanced work through supervised reading and research. Prerequisite: consent of department chairman.

372. Special Topics in Social Relations (1-3)
Continuation of S.R. 371.

373. Seminar in Sociology (3)
Intensive consideration of selected topics in contemporary theory or research in sociology. The subject matter varies from semester to semester. Prerequisite: S.R. 211 or 212, or consent of department chairman. May be repeated for credit.

374. Social Stratification (3)
Examination of concepts of stratification, such as social class, and of theories using these concepts. Consideration also of research findings which indicate the significance of stratification for society. Prerequisite: S.R. 211 or 212, or consent of department chairman.

385. Social Structure (3)
The theory of social structure considered as a basic key to the understanding of social phenomena, with attention to such concepts as interaction, position, role and role-set, status, institutionalization, equilibrium, norm, and culture. Selected propositions concerning structural relationships and processes will be examined. Prerequisite: S.R. 211 or 212, or consent of department chairman.

386. Methods in Network Analysis (3) alternate years
Study of form and process of interpersonal aspects of human behavior. Stress on ways of examining patterns of links occurring between persons and several whole networks of social relations. Prerequisite: S.R. 211-212 and 385, or consent of department chairman. Mr. Freeman.

391. Evaluation Research (3) alternate years
Application of social research methods to evaluation of the effectiveness of social programs. Consideration of measurement, research design, criteria of effectiveness, and decision-making. Prerequisite: S.R. 211-212 or consent of department chairman. Mr. Herrenkohl.

393. Experimental Social Psychology (3) alternate years
Methods and techniques for studying social psychological

phenomena in the laboratory and other controlled settings. Prerequisite: S.R. 211-212 or consent of department chairman. Mr. Rosenwein.

395. Methods in Observation (3) alternate years
Naturalistic and participant observation in uncontrolled field settings. Prerequisite: S.R. 211-212, or consent of department chairman. Mrs. Frankel.

397-398. Independent Research (3-4)
Students will conduct research under faculty supervision. Prerequisite: consent of department chairman.

399. Senior Project (3)
Independent work fulfilling major requirement. Prerequisite: S.R. 211-212, and consent of the department chairman.

For Graduates

411. Advanced Research Methods (3) fall
A basic course given in research theory and methods. Consideration given the nature of theory, hypotheses testing, the definition of variables and methods of measurement. Mr. Herrenkohl.

412. Practicum in Research Methods (3) spring
Laboratory in the design and execution of research. Emphasis on the design of measurement instruments, the application of statistical techniques, and the analysis and interpretation of data. The student will pursue an independent research project and write a research report based on it. Prerequisite: S.R. 411.

423. Social Psychology (3)
An examination of theory and research in social psychology. The objective of the course is to consider major topics and issues in relation to current research. Mr. Rosenwein.

432. Culture Patterns and Personality (3)
The psychological implications of cultural variation, including the analysis of national character. Mrs. Frankel.

434. Advanced Social Psychology (3)
Intensive consideration of selected topics in social psychology. The subject matter will vary from semester to semester on topics such as socialization, social attitudes, person perception, small group processes and communication. Messrs. Herrenkohl and Rosenwein.

464. Seminar on the Family (3)
Societal functions of marriage and the family and the relation of the institution to the social structure and demographic variables. Particular emphasis on the treatment of family disorganization. Mr. Williamson.

465. Organizational Behavior (3)
Theory and research concerning the development and functioning of organizations. Structure, goals, authority and power, communication, role conflict in large organizations. Cross-institutional comparisons of industrial, research, governmental, medical, and academic organizations.

467. Latin American Social Structure (3)
Analysis of given Latin American societies with special attention to economic and political structures. Individual projects. Mr. Williamson.

468. Advanced Urban Sociology (3)
Selected problems in urban research, urban and community planning and redevelopment. Relation of the city and the region to economic development and government functions. Mr. McIntosh.

470. Contemporary Sociological Theory (3) fall
An examination of current developments in theoretical sociology. Functional theory and conflict theory as reflected in Parsons, Merton, Coser and Dahrendorf and others. A critique of current theoretical schools. Messrs. Freeman and Sunshine.

471. Special Topics (3)
Intensive study in an area of social relations, which is appropriate to the interests and needs of the staff and students.

472. Special Topics (3)
Continuation of S.R. 471.

Institutes

The following institutes constitute a part of the university's varied research program. A description of research centers may be found on page 73. Research organizations are described on page 56.

Lawrence Henry Gipson Institute for Eighteenth-Century Studies

Background and purpose

The Lawrence Henry Gipson Institute for Eighteenth-Century Studies, established in 1971, serves as a memorial to one of America's most distinguished scholars. It helps to support the research activities of the Lehigh community of humanists and social scientists interested in developing a further understanding of the period of history epitomized in Professor Gipson's monumental life work, *The British Empire Before the American Revolution* (15 vols., 1936-1970).

Through its council, the Gipson Institute awards research grants and fellowships from the income of its endowment, a fund made possible by Professor Gipson's bequest of his entire estate to Lehigh. To further the scope of the original endowment, the council of the institute seeks additional support by promoting research and other programs related to the eighteenth century.

Research activities

The income from the endowment of the Gipson Institute, and other funds, provide for:

Faculty research grants to defray travel cost, microfilming, and other such expenses.

Graduate student grants to help support deserving students during their dissertation year.

Internal seminars to bring together the eighteenth-century interests of faculty and graduate students and to stimulate interdisciplinary research activities. These seminars are broad in scope and include faculty from neighboring institutions.

Interdisciplinary graduate courses in eighteenth-century studies to provide students, who normally concentrate on one discipline, with a grasp of other significant developments and an understanding of the rich cultural and intellectual milieu of the eighteenth century. Such courses stress the interrelationship of history, politics, literature, fine arts, philosophy, psychology and the sciences.

Annual symposia to honor the late Professor Gipson, involving distinguished scholars in eighteenth-century studies to lecture and also to discuss opportunities for further scholarly exploration.

Additional research resources for the library.

Faculty fellowships for the pursuit of research in an eighteenth-century topic.

A national Lawrence Henry Gipson Fellowship awarded on a competitive basis to a promising graduate student in eighteenth-century studies.

Educational opportunities

Among the academic departments involved in eighteenth-century studies are English, government, history, modern foreign languages, fine arts, music, philosophy, psychology, and social relations.

For further information write to the coordinator, Professor Lawrence H. Leder, Maginnes Hall, Lehigh University, Bethlehem, Pa. 18015.

Institute of Fracture and Solid Mechanics

Background and purpose

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 a unique, interdisciplinary basis.

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. The design of nuclear power plants is required to incorporate the fracture mechanics concept of safety in the presence of flaws. 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 the erosion of materials by solid or water particle impingement.

The institute centralizes many activities in the field of solid and fracture mechanics. These activities in-

clude: 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

Currently, there are several research programs being conducted in solid and fracture mechanics. Sponsors of these programs are from industrial corporations and government agencies. The programs cover the following research topics:

Fracture mechanics. Analytical: stress analysis of engineering structures weakened by flaws; spherical and cylindrical shells with mechanical imperfections; crack extension in viscoelastic and rate sensitive materials; thermoelastic analysis of crack problems; heat generation at the crack tip region in metals; vibration and impact of solids containing cracks; three-dimensional analytical and finite element studies of surface and through cracks; fracture behavior of layered and fiber-reinforced composites; elastic-plastic solutions of crack problems.

Experimental: static and dynamic fracture toughness testing of metallic, non-metallic and composite materials; crack-extension resistance curve measurements for aluminum and titanium alloys and steels; glass-to-rubbery transition temperature in viscoelastic materials; velocity measurements of running cracks; fatigue crack propagation in pressurized shells and shells under membrane load; combined loading (biaxial, tension-bending, etc.) of thin plates with cracks; photoelastic studies of stress distribution in cracked and composite bodies; environmental effects on crack propagation under static cyclic loads; fatigue crack propagation under programmed loading; gaseous hydrogen embrittlement.

Solid mechanics. Analytical and numerical methods of analysis: conformal mapping technique applied to potential solutions; two- and three-dimensional asymptotic expansions near geometric discontinuities; integral transform solutions leading to Fredholm integral equations; singular integral equations with generalized Cauchy kernels; application of the Chebyshev and Jacobi polynominals; methods based on the Gauss-Jacobi quadrature formulas; special applications of numerical treatment and finite elements to continuum problems involving singularities; convergence of finite element solutions for continuum mechanics problems.

Plates and shells; development of advanced plate and shell theories; load-deflection and instability behavior of elastic and plastic shells of revolutions; composite and sandwich shells subjected to static and dynamic loadings; dynamics of magneto-elastic 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 science, civil engineering, chemistry and biology.

For further information write to the director, Professor George C. M. Sih, Packard Laboratory, Lehigh University, Bethlehem, Pa. 18015.

Institute for Metal Forming

Background and purpose

The Institute for Metal Forming, sponsored by the department of metallurgy and materials science, was formally established in 1970 with the following objectives: 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 which are part of the facilities of the institute.

In addition, an important part of the effort of the institute is the preparation of educational programs using the latest audiovisual techniques. These programs are used in the classroom and in institute-sponsored seminars on campus and at industrial facilities.

Long-range planning, together with major equipment acquisitions and construction, is supported by

University funds, federal funds, and an industrial consortium.

Research activities

Several of the current research areas are: hydrostatic extrusion; pressure-induced ductility; flow through converging conical dies; effect of holes, inclusions and pressure on the tensile properties; friction measurement; cladding and forming of composite materials; forming of polymers; deep drawing, impact extrusion and ironing; powder consolidation.

Educational opportunities

Students interested in metal forming should refer to course offerings in the departments of metallurgy and materials science and mechanical engineering and mechanics. In addition, the institute offers special informal seminars and lectures for graduate students.

For further information write to the director, Professor Betzalel Avitzur, Whitaker Laboratory, Lehigh University, Bethlehem, Pa. 18015.

Institute for Pathobiology

Background and purpose

The Institute for Pathobiology was established in 1971 as an independent research unit at Lehigh. However, it became a division of the Center for Health Sciences when the latter was recognized in January, 1973.

The personnel affiliated with the institute are involved in research and graduate training in several aspects of the biomedical sciences. Specifically, the staff is concerned with research in the areas of microbiology, protozoan and metazoan parasitology, immunology, biological and chemical control of vectors of disease-causing organisms, toxicology, medical and public health ecology, and selected areas of developmental biology.

Research activities

Research currently being conducted at the institute includes the isolation and characterization of microorganisms potentially useful in the control of the snail transmitters of schistosomiasis, fascioliasis, and other helminthic diseases; the development of new specific molluscicides and insecticides; studies on the biochemistry and physiology of parasitic nematodes and trematodes with the objective of developing new chemotherapeutic compounds; examination of immune mechanisms in invertebrates: isolation and characterization of toxins in edible marine animals; and studies on the chemical basis of development of model organisms.

Educational opportunities

Although graduate students participating in the interdisciplinary M.S. and Ph.D. program in physiological chemistry are enrolled in the department of chemistry, they are provided with research facilities and support by the Institute for Pathobiology as well as other divisions of the Center for Health Sciences.

For further information concerning graduate and postdoctoral research opportunities at this institute, contact Dr. Thomas C. Cheng, the director, at Chandler Laboratory, Lehigh University, Bethlehem, Pa. 18015.

National Printing Ink Research Institute

Background and purpose

The National Printing Ink Research Institute (NPIRI) was established at Lehigh in 1946 to carry out fundamental research for the printing ink industry and thus is Lehigh's oldest research institute. In 1966, NPIRI was incorporated into the newly formed Center for Surface and Coatings Research because its activities formed an integral part of the center's area of interest. Until 1970, NPIRI was housed in Chandler Laboratory along with the Department of Chemistry, but then moved with the center into Sinclair Laboratory, which was built in large part with contributions from the printing ink industry.

The purpose of NPIRI is to carry out fundamental research in its areas of specialization, i.e., to apply the principles of colloid, surface, and polymer chemistry to the broadest aspects of printing ink and paper, as well as to the printing process itself.

NPIRI's financial support comes principally from research contracts and grants. Current sponsors include the National Association of Printing Ink Manufacturers, U.S. Postal Service and National Science Foundation, as well as various companies.

Research activities

NPIRI's traditional areas of research are dispersion of pigments, rheology of printing inks, surface chemistry of lithography, printability, test methods, and instrumentation. More recently, its research interests have expanded to include computer color-matching, safety and health aspects of printing inks, optical properties of ink films, recycling of wastepaper, and ultraviolet light-cured inks.

Its laboratories are completely equipped with proof presses and various test instruments to carry out work in these areas. Of particular interest is the Color Science Laboratory, which is equipped for all types of color measurement, and the Printability Laboratory, which is equipped to handle most printing problems.

Educational opportunities

NPIRI offers opportunities for graduate study leading to the M.S. and Ph.D. degrees. Its graduate students are drawn from the various academic departments, e.g., the departments of chemistry, chemical engineering, and psychology. NPIRI also offers undergraduate research opportunities, such as theses subjects tailored to the individual student or larger programs involving several students (for example, the 1974 National Science Foundation summer project on recycling of wastepaper, which involved six undergraduates).

Students who are interested in NPIRI's areas of specialization are welcome to associate with its program and to use its experimental facilities. Research topics are selected by mutual agreement between the student and his faculty advisor. Prospective students are encouraged to explore these opportunities with the NPIRI director.

NPIRI's other educational activities include a biennial Summer Course in Printing Ink Technology as well as meetings on special topics, e.g., Rheology of Printing Inks in 1972, Ecology in the Graphic Arts Industry in 1972 and 1973, and Raw Materials Supply in the Printing Ink Industry in 1974. Other activities include the Test Methods Index, a compilation of tests applied to inks and coatings, and the Raw Materials Data Handbook, a compilation of the physical, chemical, fire hazard and safety hazard properties of the ingredients used in printing inks.

For further information, contact the director, Professor John W. Vanderhoff, Sinclair Laboratory, Lehigh University, Bethlehem, Pa. 18015.

The Wetlands Institute

Background and purpose

This facility is a joint activity between The Wetlands Institute, incorporated as a nonprofit organization, and Lehigh University. The University operates the institute under the Center for Marine and Environmental Studies at Lehigh.

The Wetlands Institute, which commenced operations in May, 1972, is located on a 34-acre site on the edge of a coastal salt marsh near Stone Harbor, N.J. It is a research and teaching field station and, following the practice of other seaside marine research stations, educators and researchers from other colleges and universities may use the facilities for research and education which falls within the general objectives of the institute. These are: (1) to increase the understanding of the natural processes controlling the wetlands ecosystems through fundamental research; (2) to investigate the renewability of the natural resources and to increase the biotic potential of the wetlands area; (3) to ascertain the effects of disturbances caused by man's activities, and to find methods of minimizing these effects through practical and applied research; (4) to provide factual scientific information which can serve others as a basis on which to make intelligent decisions for the long-range beneficial multiple use of coastal areas; (5) to train scientists and engineers in methods of solving and of preventing problems in the coastal zones; and (6) to educate the general public, both resident and vacationing, in the importance of wetlands to the general ecology of coastal areas, to the need for preserving and for enhancing the wetlands in maintaining those aspects of the coastal zones that make them attractive to residents and vacationers, and what each person can do to protect the environment.

The Wetlands Institute provides facilities for year-round studies of the surrounding environment and includes: six research laboratories, dormitory space and kitchen facilities, lecture room and demonstration area, flowing salt water system, maintenance shop, scientific laboratory equipment, and a variety of outboard motor skiffs.

Research activities

Current research interests of the institute staff include: salt marsh food webs; physiological criteria for determining sublethal effects of various environmental parameters; sedimentation studies; geochemistry of coastal salt marsh waters; beach sand studies; microbial mineralization of cellulose and chitin in salt marshes; new techniques for identification of planktonic fish eggs; viral diseases of fish; effect of sewage on marine organisms; and aquaculture of fish and shellfish.

Educational opportunities

Formal graduate studies are offered through the graduate programs in the various departments of the University. One facet of graduate student training is related to preparation of scientists to continue studies of the coastal area; the other is concerned with providing school science teachers with sufficient training so that they are able to return to the classroom and pass on vital information about the tidal wetlands to their students. In conjunction with teacher training, every effort is made to provide lectures, demonstrations and tours of the wetlands for classes. Selected undergraduate courses also are offered as part of the summer program. In addition, minicourses are offered during the year. These courses, which cover different aspects of the marine environment may be taken for one unit of credit at Lehigh.

For further information write to the director, Professor Sidney S. Herman, 217 Williams Hall, Lehigh University, Bethlehem, Pa. 18015.

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B.S., Kutztown State, 1959; M.A., Lehigh, 1961; M.Ed., 1964; Ed.D., 1966.

Edward Kenneth Levy (1967, 1972)
Associate Professor of Mechanical Engineering and Mechanics
B.S., Maryland, 1963; S.M., M.I.T., 1964; Sc.D., 1967.

Willard Deming Lewis (1964)
President
A.B., Harvard, 1935; B.A., Oxford, 1938; Ph.D., Harvard, 1941; M.A., Oxford, 1945; LL.D., Lafayette, 1965; L.H.D., Moravian, 1966; LL.D., Muhlenberg, 1968; Eng. D., Lehigh, 1974.

Joseph Francis Libsch (1946, 1969)
Alcoa Professor of Metallurgy and Materials Science and Vice President for Research
B.S., M.S., M.I.T., 1940; Sc.D., 1941. P.E., Pennsylvania, 1947.

John Orth Liebig, Jr. (1946, 1970)
Professor of Civil Engineering
B.S., Lehigh, 1940; M.S., 1949. P.E., Pennsylvania, 1951.

Thelma Lifland (1971)
Instructor in School of Education
B.A., Brooklyn, 1956; M.Ed., Rutgers, 1960.

John Ralph Lindgren (1965, 1969)
Associate Professor and Chairman of Philosophy
B.S., Northwestern, 1959; M.A., Marquette, 1961; Ph.D., 1963.

Lora Liss (1974)
Affirmative Action Officer
B.A., Queens College, 1965; M.A., N.Y.U., 1967; Ph.D., 1969.

Benjamin Litt (1970, 1973)
Associate Professor of Management
B.S., Brooklyn Polytechnic, 1950; M.S., Stevens Institute, 1957; M.B.A., N.Y.U., 1964; Ph.D., 1970.

Roger C. Loeb (1971)
Assistant Professor of Psychology
A.B., Bucknell, 1967; Ph.D., Cornell, 1972.

Barbara Long (1966, 1971)
Programmer/Analyst, Administrative Systems Office

Francis A. Long (1971)
Lecturer in Electrical Engineering
B.S., Northeastern.

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Associate Professor of Chemistry
B.A., Reed College, 1955; Ph.D., Washington State, 1960.

Le-Wu Lu (1957, 1969)
Professor of Civil Engineering
B.S., National Taiwan, 1954; M.S., Iowa State, 1956; Ph.D., Lehigh, 1960.

Robert Alan Lucas (1958, 1969)
Associate Professor of Mechanical Engineering
B.S., Lehigh, 1957; M.S., 1959; Ph.D., 1964.

John Luckhardt (1973)
Assistant Football and Lacrosse Coach
B.S., Purdue, 1967; M.S., 1970.

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Associate Professor of Accounting
B.A., National Taiwan, 1957; M.S., Illinois, 1961; Ph.D., Ohio State, 1965.

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B.S., Lehigh, 1965; M.A., 1968; Ed.D., 1969.

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Professor of Chemical Engineering
B.S., Penn State, 1955; M.B.A., Rutgers, 1958; M.S., 1962; Ph.D., Delaware, 1963.

George Buchanan MacDonald (1964, 1972)
Assistant Professor of English
A.B., Boston College, 1962; M.A., Lehigh, 1964; Ph.D., 1972.

Helen P. Mack (1974)
Science Cataloger
B.A., Moravian, 1973; M.S.L.S., Drexel, 1974.

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Director of Libraries
B.A., Lehigh, 1938; M.A., 1949.

Alister Kenneth MacPherson (1971, 1974)
Associate Professor of Mechanical Engineering and Mechanics
B.S., University of Sydney (Australia), 1957; M.S., 1965; Ph.D., 1967.

Mary Isabelle Malone (1966)
Secretary to the President
B.A., Rosary College, 1945.

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Professor of Biology
B.A., Lehigh, 1948; M.S., 1949; Ph.D., 1958.

Arthur Howard Mann (1965, 1970)
Associate Dean of Students
B.A., Wesleyan, 1940; S.T.B., General Theological Seminary, 1944.

Harold R. Manns (1974)
Assistant Professor of Military Science
B.S., Lehigh, 1965; M.B.A., 1974. Captain, U.S. Army.

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Professor of Chemistry, and Director of the Polymer Laboratory, Materials Research Center
B.Sc., McMaster University (Ontario), 1949; M.Sc., 1950; Ph.D., 1956.

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Systems Analyst, Administrative Systems Office, and Assistant Professor of Education
B.S., Lehigh, 1964; M.Ed., 1965; Ph.D., 1970.

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Visiting Instructor in Social Relations
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B.S., Illinois State University, 1968; M.S., 1969.

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Instructor in Modern Foreign Languages
B.A., Rosemont, 1967; M.A., Bryn Mawr, 1969.

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Physiotherapist, Health Service

Joseph Abele Maurer (1947, 1964)
Professor of Classics
B.A., Moravian, 1932; M.A., Lehigh, 1936; Ph.D., Pennsylvania, 1948.

Gregory T. McAllister, Jr. (1965, 1972)
Professor of Mathematics
B.S., St. Peter's College, 1956; Ph.D., Berkeley, 1962.

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Assistant to the Director of Admission
B.S., Lehigh, 1973.

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Consultant, Office of the Vice President for Development
B.S., 1930; M.A., 1933; L.H.D., Washington & Jefferson.

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Professor and Chairman of Physics
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Humanities Cataloger, Linderman Library
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B.A., Columbia College, 1959; M.S., Rensselaer, 1965; Ph.D., 1971.

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A.B., George Washington, 1959; M.A., 1960; Ph.D., 1965.

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B.S., C.U.N.Y. (Brooklyn), 1964; Ph.D., Stanford, 1968.

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Director of Physical Plant
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B.S., Lehigh, 1960; M.S., 1963; Ph.D., 1967.

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Associate Professor of Mechanics
B.S.M.E., Purdue, 1933; M.S., Michigan, 1946. P.E., Michigan, 1955.

Alexis Ostapenko (1957, 1965)
Professor of Civil Engineering
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Visiting Lecturer in Education
A.B., Muhlenberg, 1949; M.Ed., Temple, 1950; Ed.D., 1962.

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Assistant Professor of Electrical Engineering
B.A., Cornell, 1966; M.S., Pennsylvania, 1969; Ph.D., 1972.

Eric Van Tine Ottervik (1966, 1969)
Vice President for Planning
B.S., Carnegie-Mellon, 1959; M.A., Pittsburgh, 1961; Ph.D., 1966.

Jerzy Antoni Owczarek (1960, 1965)
Professor of Mechanical Engineering
Dipl. Ing., Polish University College (London), 1950; Ph.D., University of London, 1954.

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Professor of Biology
B.A., Williams, 1934; M.A., 1936; Ph.D., Harvard, 1940.

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Assistant Professor of History
B.A., Oberlin, 1966; M.A., Wisconsin, 1960; Ph.D., 1972.

Anthony Packer (1946, 1950)
Director in Charge of Fields
B.S., St. Lawrence, 1938.

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Accountant, Fritz Engineering Laboratory

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Assistant Professor of Education
B.S., California State (Pa.), 1967; M.A., West Virginia, 1968; Ed.D., 1971.

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Assistant Director of Counseling and Testing and Assistant Professor of Education
B.A., Queen's College, 1956; M.S., Penn State, 1958; Ph.D., 1968.

Lloyd C. Parker (1971)
Centennial School Teacher
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James Marshall Parks (1967, 1970)
Professor of Geology and Director, Center for Marine and Environmental Studies
A.B., Kansas, 1948; M.S., Wisconsin, 1949; Ph.D., 1951.

Preston Parr (1949, 1970)
Dean and Vice President for Student Affairs
B.S., Lehigh, 1943; M.S., 1944.

Ruth B. Parr (1967, 1968)
Centennial School Teacher
B.S., Simmons, 1945; M.A., Lehigh, 1969.

John W. Paul (1974)
Instructor in Accounting
B.A., Cornell, 1965; M.B.A., Lehigh, 1970. C.P.A., Florida, 1972.

John H. Pearson (1972)
Associate Professor of English and Head, Division of Speech and Drama
B.A., Baylor, 1958; M.F.A., Penn State, 1968.

Alan Wiggins Pense (1957, 1971)
Professor of Metallurgy and Materials Science
B.S., Cornell, 1957; M.S., Lehigh, 1959; Ph.D., 1962.

Joseph Petronio (1968)
Bursar
B.S., King's College, 1960.

Robert L. Pettigrew (1969)
Computer Analyst
B.S., Lehigh, 1969.

Heinz G. Pfeiffer (1975)
Adjunct Professor in Chemistry
B.A., Drew University, 1941; M.A., Syracuse, 1944; Ph.D., California Institute of Technology, 1949.

Robert A. Pfenning (1969, 1972)
Coordinator, User Services, Computing Center
B.A., Wesleyan, 1962; M.B.A., Michigan, 1964.

Dennis A. Pickering (1972)
Assistant Professor of Education
B.S., Ohio State, 1965; M.A., 1967; Ed.D., Ball State, 1972.

Warren Aiken Pillsbury (1962, 1965)
Associate Professor of Economics
A.B., New Hampshire, 1953; M.S., Florida State, 1958; Ph.D., Virginia, 1963.

Arthur Everett Pitcher (1938, 1960)
Distinguished Professor and Chairman of Mathematics
A.B., Case-Western Reserve, 1932; A.M., Harvard, 1933; Ph.D., 1935; D.Sc. (Hon.), Case-Western Reserve, 1957.

Louis J. Plebani (1974)
Instructor of Industrial Engineering
B.S., Lehigh, 1968; M.S., American University, 1972.

Lucille H. Pleiss (1961, 1971)
Administrative Assistant to Director, Health Service
R.N., St. Luke's, 1949.

Gary Wayne Poehlein (1965, 1969)
Associate Professor of Chemical Engineering
B.S., Purdue, 1958; Ph.D., 1966.

Harry L. Price (1974)
Instructor in Education
B.A., Swarthmore, 1960; M.Ed., Lehigh, 1974.

Hayden Nelson Pritchard (1964, 1970)
Associate Professor of Biology
A.B., Princeton, 1955; M.S., Lehigh, 1960; Ph.D., 1963.

Thomas A. Pugliese (1972)
Head Basketball Coach
A.A., Sacramento City College, 1961; B.A., Sacramento State, 1963.

Carroll W. Pursell (1974)
Mellon Professor of History
B.A., University of California at Berkeley, 1956; M.A., Delaware, 1958; Ph.D., Berkeley, 1962.

William Leroy Quay (1963, 1970)
Dean of Students
A.B., Muhlenberg, 1956; A.M., Pennsylvania, 1957; Ph.D., Lehigh, 1969.

Clifford Steven Queen (1972)
Assistant Professor of Mathematics
Ph.D., Ohio State, 1969.

Shelden Henry Radin (1963, 1974)
Professor of Physics
B.S., Worcester Polytechnic, 1958; M.S., Yale, 1969; Ph.D., 1963.

Harry B. Ramsey (1963, 1971)
Associate Executive Director, Alumni Association and Editor, Lehigh Alumni Bulletin
B.A., Lehigh, 1950.

Viswanatha Raja Gopala Rao (1972)
Assistant Professor of Mathematics
B.Sc., Andhra U. (Waltair, India), 1964; M.S., 1965; A.M., Illinois, 1967; Ph.D., 1972.

Carol D. Rauch (1968, 1970)
Librarian, Computing Center

Gerhard Rayna (1955, 1969)
Associate Professor of Mathematics
A.B., Harvard, 1952; M.A., Princeton, 1953; Ph.D., 1965.

Helen Z. Rayner (1963, 1969)
Administrative Assistant, Placement Services

Georgia Emily Raynor (1961, 1968)
Assistant Librarian, Cataloging
A.B., Chatham, 1945; M.A., Lehigh, 1954; M.S. in L.S., Columbia, 1954.

Richard James Redd (1958, 1970)
Professor and Chairman of Fine Arts
B.Ed., Toledo, 1953; M.F.A., Iowa, 1958.

Estoy Reddin (1964, 1967)
Associate Professor of Education
B.S., Pennsylvania, 1932; M.S., 1956; Ed.D., 1964.

John K. Redmon (1970)
Lecturer in Electrical Engineering
B.S., Newark College of Engineering, 1942; M.S., Stevens Institute, 1949; M.S., Worcester Polytechnic, 1970. P.E., New Jersey, 1961; Pennsylvania, 1970.

Robert F. Reeves (1968, 1972)
Assistant Dean of Students
B.A., Drew, 1966.

Robert E. Reidnauer (1961, 1974)
Programmer/Analyst, Administrative Systems Office

Frederick Eugene Ressler (1952, 1964)
Associate Registrar
B.A., Lehigh, 1952.

Rodney Earl Ressler (1947, 1964)
Assistant Registrar

Lucius J. Riccio (1972)
Assistant Professor of Industrial Engineering
B.S., Lehigh, 1969; M.S., 1970; Ph.D., 1973.

Adrian F. Richards (1969)
Professor of Oceanography and Ocean Engineering and Director, Marine Geotechnical Laboratory, CMES
B.S., New Mexico, 1951; Ph.D., Scripps Institution of Oceanography, 1957.

Berry Gargal Richards (1969)
Associate Librarian, Mart Science and Engineering Library
A.B., Vassar, 1952; M.L.S., New York at Albany, 1969.

Wallace James Richardson (1952, 1959)
Professor of Industrial Engineering
B.S., U.S. Naval Academy, 1941; M.S., Purdue, 1948. P.E., Delaware, 1956.

Richard C. Richardson, Jr. (1967)
Visiting Lecturer in Education
B.S., Castleton State College, 1954; M.A., Michigan State 1958; Ph.D., Texas, 1963.

Martin L. Richter (1965, 1972)
Associate Professor of Psychology
B.A., Rutgers, 1960; Ph.D., Indiana, 1965.

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Head Reference Librarian, Linderman Library
B.A., Penn State, 1952; M.S. in L.S., Drexel, 1953.

Alice Duffy Rinehart (1964, 1974)
Associate Professor of Education and Coordinator of Educational Placement
B.A., Smith, 1947; M.Ed., Lehigh, 1965; Ed.D., 1969.

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Administrative Assistant, Fritz Engineering Laboratory
A.A., Toepaste Kunsten (Maastericht, Holland), 1969.

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Assistant to the Vice President for Research
B.S., Lehigh, 1961; S.M., M.I.T., 1963; Sc.D., 1966.

Ronald Samuel Rivlin (1967)
Centennial University Professor of Mathematics and Mechanics and Director, Center for the Application of Mathematics
B.A., Cambridge (England), 1937; M.A., 1939; Sc.D., 1952.

Richard Roberts (1964, 1969)
Associate Professor of Mechanical Engineering
B.S., Drexel, 1961; M.S., Lehigh, 1962; Ph.D., 1968.

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Director, Computing Associates Program; Manager, Special Projects, Computer Center
B.E., Johns Hopkins, 1949.

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Assistant to the Editor, Alumni Bulletin
B.A., Muhlenberg, 1968.

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Associate Professor of Mechanical Engineering and Mechanics
B.S., Bucknell, 1964; M.S., Lehigh, 1965; Ph.D., 1968.

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Assistant Professor of Chemistry
B.S., M.S., Brooklyn Polytechnic, 1966; Ph.D., Clarkson, 1971.

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B.A., Berkeley, 1962; M.A., 1963; Ph.D., Michigan, 1970.

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Director of Physical Planning
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B.A., Arizona, 1970; M.S.L.S., Syracuse, 1974.

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Professor of Philosophy and Adjunct Professor of Psychology
B.A., Pennsylvania, 1942; M.A., 1943; Ph.D., Columbia, 1949.

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Associate Professor of Government and Head, Division of Urban Studies
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Professor of Geology and Chairman of Geological Sciences
B.A., Lehigh, 1943; M.S., 1948; Ph.D., Johns Hopkins, 1952.

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Sc.B., Brown, 1960; M.S., Princeton, 1963; Ph.D., Brown, 1965.

Norman Harold Sam (1962, 1970)
Professor of Education and Director, Summer Session
B.S., Pittsburgh, 1951; M.Ed., 1955; Ed.D., 1962.

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Instructor in Education
B.S., S.U.N.Y. at Buffalo, 1960; M.Ed., Lehigh, 1969.

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Assistant Football and Track Coach
B.S., Buffalo, 1960; M.Ed., 1968.

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Murray Schechter (1963, 1968)
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B.S., Lehigh, 1955; M.A., Princeton, 1958; Ph.D., 1960.

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Assistant Treasurer
B.S., Lehigh, 1944.

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B.S., Portland, 1965; Ph.D., Penn State, 1970.

Stanley Robert Schultz (1966)
Instructor in Physical Education, Varsity Baseball Coach
B.A., Trenton State, 1964.

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Professor of Economics and Finance
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Assistant Director of University Publications
B.A., Juniata, 1964; B.F.A. and M.F.A., Yale, 1970.

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Bruce M. Smackey (1971)
Assistant Professor of Management and Marketing
B.S., Rensselaer, 1962; M.S., Case-Western Reserve, 1964; Ph.D., Rensselaer, 1969.

David B. Smith (1972)
Instructor in Economics
B.S., Lehigh, 1969; M.S., 1970; Ph.D., 1972.

Gerald Francis Smith (1965)
Professor, Center for the Application of Mathematics
B.S., Buffalo, 1953; Ph.D., Brown, 1956.

Wesley Richard Smith (1958, 1968)
Professor of Physics
B.S., Lehigh, 1950; M.S., 1951; Ph.D., Princeton, 1957.

Oles M. Smolansky (1963, 1970)
Professor and Chairman of International Relations
A.B., N.Y.U., 1953; A.M., Columbia, 1955; Ph.D., 1959.

Mervin Philip Smolinsky (1970)
Adjunct Professor of Psychology
B.A., Temple, 1951; M.S., Pittsburgh, 1966; Ph.D., 1969.

Donald Morgan Smyth (1971, 1973)
Director, Materials Research Center and Professor, Metallurgy and Materials Science and Chemistry
B.S., Maine, 1951; Ph.D., M.I.T., 1954.

Max Donald Snider (1946, 1973)
Professor of Marketing and Associate Dean of the College of Business and Economics
B.S., Illinois, 1936; M.S., 1937; M.B.A., Stanford, 1941.

Andrew Kagey Snyder (1967, 1969)
Associate Professor of Mathematics
B.A., Swarthmore, 1959; M.A., Colorado, 1961; Ph.D., Lehigh, 1965.

Barbara E. Solt (1970)
Coordinator of Volunteer Community Services
A.B., Muhlenberg, 1965; M.S.S.W., Columbia, 1967.

Richard N. Sopko (1960)
Photographer, Fritz Engineering Laboratory

Harry W. Soul (1974)
Lecturer in Mathematics
B.A., Kenyon College, 1969; M.S., Lehigh, 1971.

Leslie H. Sperling (1967, 1973)
Associate Professor of Chemical Engineering
B.S., Florida, 1954; M.A., Duke, 1957; Ph.D., 1959.

Robert Steacy Sprague (1957, 1966)
Professor of Chemistry
B.S., Washington & Jefferson, 1943; Ph.D., Illinois, 1949.

Richard Moore Spriggs (1964, 1972)
Vice President for Administration and Professor, Metallurgy and Materials Science
B.S., Penn State, 1952; M.S., Illinois, 1956; Ph.D., 1958.

Duane E. Stackhouse (1969)
Associate Director, Health Service
B.S., Juniata, 1957; M.D., Temple, 1961.

William Butler Stafford (1967, 1972)
Associate Professor of Education
A.B., Ohio, 1954; M.A., 1955; Ed.D., Indiana, 1965.

William Edward Stanford (1967, 1970)
Director of Undergraduate Financial Aid
B.A., Drew, 1962.

Nicolette Stasko (1973)
Centennial School Teacher
B.A., Penn State, 1971.

John Stohler Steckbeck (1962, 1974)
Associate Professor of Physical Education and Director, Intramurals and Recreation
B.S., West Chester, 1936; M.Sc., Pennsylvania, 1951.

Fred P. Stein (1963, 1971)
Professor of Chemical Engineering
B.S., Lehigh, 1956; M.S.E., Michigan, 1957; Ph.D., 1960.

Olive Stengel (1966)
Circulation Supervisor, Library

Gilbert Allan Stengle (1960, 1970)
Professor of Mathematics
B.E.P., Cornell, 1954; M.S., Wisconsin, 1957; Ph.D., 1961.

Doyle Keaton Stewart (1973)
Assistant Professor of Education
B.S., Kansas State at Pittsburg, 1960; M.S., 1964.

Stephen Michael Stillman (1973)
Assistant Professor of Education
B.S., Pittsburgh, 1966; M.Ed., Teachers College, 1968; Ph.D., Ohio State, 1971.

Richard L. Stocker (1973)
Assistant Professor of Geology
B.A., Lehigh, 1964; M.S., 1966; M.Phil., 1969; Ph.D., Yale, 1972.

John A. Stoops (1959, 1966)
Professor and Dean of the School of Education
B.S., California State College, 1948; M.S., Pennsylvania, 1949; Ed.D., 1960.

Robert Daniel Stout (1939, 1960)
Professor of Metallurgy and Materials Science and Dean of the Graduate School
B.S., Penn State, 1935; M.S., Lehigh, 1941; Ph.D., 1944; D.Sc., Albright, 1967. P.E., Pennsylvania, 1946.

Rita M. Strasburger (1974)
Instructor in Fine Arts
A.B., University of California, 1970; M.A., Illinois, 1972.

Karol Strelecki (1971)
Centennial School Teacher
B.S., Rutgers, 1961; M.S., Temple, 1970.

Joseph Strickland, Jr. (1972)
Centennial School Teachers,
B.A., Lehigh, 1972; M.Ed., 1974.

James Edward Sturm (1956, 1972)
Professor of Chemistry
B.A., St. John's (Minnesota), 1951; Ph.D., Notre Dame, 1957.

Robert Joseph Sullivan (1962, 1969)
Professor of Journalism
B.A., Syracuse, 1947; M.A., 1951.

John R. Sumner (1972)
Assistant Professor of Geology
B.S., Arizona, 1966; M.S., 1968; Ph.D., Stanford, 1971.

Morris H. Sunshine (1972)
Professor of Social Relations
B.A., Missouri, 1949; M.A., 1954; Ph.D., Northwestern, 1962.

Alfred Kriss Susskind (1968)
Professor and Chairman of Electrical Engineering
B.E.E., Brooklyn Polytechnic, 1948; S.M., M.I.T., 1950.

Hugh T. Sutherland (1967)
Instruments Associate, Fritz Engineering Laboratory

John F. Szwed (1975)
Visiting Lecturer of Social Relations
B.Sc., Ohio State, 1959; M.A., 1960; Ph.D., 1965.

Harry O. Tachovsky (1971)
Centennial School Teacher
B.S., Kutztown State, 1970; M.Ed., Lehigh, 1973.

Donald Lee Talhelm (1960)
Instructor in Electrical Engineering
B.S., Lehigh, 1959; M.S., 1960.

Lambert Tall (1955, 1970)
Professor of Civil Engineering
B.E., Sydney (Australia), 1954; M.S., Lehigh, 1957; Ph.D., 1961.

Stephen Kenneth Tarby (1961, 1973)
Professor of Metallurgy and Materials Science
B.S., Carnegie-Mellon, 1956; M.S., 1958; Ph.D., 1962.

Robert Sayre Taylor, Jr. (1950)
Legal Counsel
B.A., Lehigh, 1925; LL.B., Pennsylvania, 1928.

Everett Anderson Teal (1945)
Director of Placement Services
B.S., Ball State, 1932; M.A., Columbia, 1941.

Theodore Alfred Terry (1951, 1968)
Associate Professor of Mechanical Engineering
B.S., Drexel, 1950; M.S., Lehigh, 1951; Ph.D., 1963. P.E., Pennsylvania, 1957.

David A. Thomas (1968, 1970)
Professor of Metallurgy and Materials Science and Associate Director, Materials Research Center
B.S., Cornell, 1953; Sc.D., M.I.T., 1958.

Robert J. Thornton (1970, 1974)
Associate Professor of Economics
A.B., Xavier, 1965; M.A., Illinois, 1967; Ph.D., 1970.

Ferdinand Thun (1973)
Advisor-Bequests and Trusts
B.S., Lehigh, 1956; M.B.A., Harvard, 1960.

James A. Tiefenbrunn (1969, 1972)
Assistant Director of Residence and Assistant Dean of Students
B.S., Lehigh, 1966; M.B.A., 1972.

Charles Leon Tipton (1964, 1971)
Professor of History
B.A., Southern California, 1958; M.A., 1961; Ph.D., 1964.

Jane T. Todd (1974)
Centennial School Teacher
B.A., Delaware, 1970.

Barbara Traister (1973)
Assistant Professor of English
B.A., Colby College, 1965; M.Phil., Yale, 1968; Ph.D., 1973.

Doris Mae Transue (1964)
Nurse, Health Service
R.N., St. Luke's, 1947.

Seymour Traub (1973)
Assistant Professor of Law
B.S., N.Y.U., 1961; M.B.A., Lehigh, 1965; J.D., Georgetown, 1969.

Louis Reed Tripp (1964)
Frank L. Magee Professor of Business Administration
B.A., Union, 1934; Ph.D., Yale, 1942.

Sandra Lee Trippett (1973, 1974)
Assistant to the Bursar
B.A., Lehigh, 1973.

David Trutt (1965, 1971)
Associate Professor of Mathematics
B.S., Lafayette, 1959; M.S., Brown, 1962; Ph.D., Purdue, 1964.

John L. Tucker (1975)
Instructor of Finance
B.S. Engr., Maryland, 1967; M.B.A., S.U.N.Y. at Buffalo, 1971.

B. Thayer Turner (1970)
Varsity Wrestling Coach
B.S., Lehigh, 1961.

Linda L. Turner (1972)
Assistant to the Director of Admission
B.A., Dickinson, 1971.

John Charles Turoczi (1970, 1973)
Lecturer in Education
A.B., Muhlenberg, 1964; M.Ed., Lehigh, 1967; Ed.D., 1972.

LeRoy J. Tuscher (1971)
Assistant Professor of Education
B.S., Northern State, 1958; M.A., Stanford, 1964; Ph.D., Florida State, 1971.

Dale Tyson, Jr. (1974)
Lecturer in Education
B.A., Adelbert (Western Reserve), 1956; M.A., 1958; Ed.D., 1963.

Kenneth Kai-Ming Tzeng (1969, 1973)
Associate Professor of Electrical Engineering
B.S., National Taiwan, 1959; M.S., Illinois, 1962; Ph.D., 1969.

S. Herbert Unterberger (1965)
Adjunct Professor in Economics
B.S., Pennsylvania, 1934; M.A., 1935; Ph.D., 1960.

Dean Pearson Updike (1965, 1973)
Associate Professor of Mechanics
B.S., Princeton, 1957; M.S., N.Y.U., 1960; Ph.D., Brown, 1964.

Paul J. Usinowicz (1972)
Assistant Professor of Civil Engineering
B.S., Iowa, 1968; M.S., 1969; Ph.D., Michigan, 1970.

Victor Manuel Valenzuela (1957; 1969)
Professor of Spanish, Modern Foreign Languages and Literatures
B.A., San Francisco State, 1951; M.A., Columbia, 1952; Ph.D., 1965.

John W. Vanderhoff (1970, 1974)
Professor of Chemistry, Director, National Printing Ink Research Institute and Associate Director, Center for Surface and Coatings Research
B.S., Niagara, 1947; Ph.D., Buffalo, 1951.

Anje C. van der Naald (1969, 1973)
Associate Professor of Spanish, Modern Foreign Languages and Literatures
B.A., Carleton University (Ottawa), 1963; M.A., Illinois, 1965; Ph.D., 1967.

John Andrews Van Eerde (1960, 1963)
Professor of Romance Languages and Literatures
A.B., Harvard, 1938; M.A., 1939; Ph.D., Johns Hopkins, 1953.

Nan Van Gieson (1973)
Assistant to the Provost
B.A., Russell Sage, 1958; M.Ed., Lehigh, 1967; Ed.D., 1969.

David Alan VanHorn (1962, 1967)
Professor and Chairman of Civil Engineering
B.S., Iowa State, 1951; M.S., 1956; Ph.D., 1959. P.E., Iowa, 1957.

Wesley Johnson Van Sciver (1962, 1965)
Professor of Physics
B.S., M.I.T., 1940; Ph.D., Stanford, 1954.

Eric Varley (1967)
Professor, Center for the Application of Mathematics
B.Sc., University of Manchester (England), 1955; M.Sc., 1957; Ph.D., Brown, 1961.

Ramamirthan Venkataraman (1968, 1974)
Associate Professor, Center for the Application of Mathematics
B.S., St. Joseph's College (Madras, India), 1960; M.A., 1961; Ph.D., Brown, 1968.

Kenneth J. Veprek (1968)
Technical Coordinator, Mart Science and Engineering Library
B.S., Newark College of Engineering, 1953; M.S.L.S., Drexel, 1966.

Thomas Joseph Verbonitz (1967, 1973)
Director of Administrative Services
B.S., Lehigh, 1958; M.B.A., 1960.

John F. Vickrey (1961, 1974)
Professor of English
Ph.B., Chicago, 1949; A.M., 1952; Ph.D., Indiana, 1960.

Ricardo Viera (1974)
Instructor of Fine Arts and Director of Exhibitions
B.F.A., Tufts, 1973; M.F.A., Rhode Island School of Design, 1974.

James Harold Wagner (1949, 1951)
Registrar
B.A., Gettysburg, 1947; M.A., Pennsylvania, 1950.

D. Alexander Waldenrath (1968, 1969)
Associate Professor of German, Modern Foreign Languages and Literatures
B.A., Berkeley, 1961; M.A., 1964; Ph.D., 1969.

John E. Walker (1967, 1972)
Director of Computing Center and Associate Professor of Economics
B.S., Clemson, 1958; Ph.D., Virginia, 1963.

Richard M. Walsh (1974)
Assistant Professor of Military Science
A.B., Seton Hall, 1966; M.A., Lehigh, 1974. Captain, U.S. Army.

Elvin Galen Warfel (1966, 1971)
Associate Professor of Education
B.S., Shippensburg State, 1950; M.Ed., Penn State, 1958; Ed.D., Columbia, 1967.

Stuart K. Webster (1972)
Instructor in Accounting
B.A., Heidelberg College, 1964; M.B.A., Bowling Green, 1965. C.P.A., Iowa, 1969.

Ben L. Wechsler (1974)
Assistant Professor of Industrial Engineering
B.S., Carnegie, 1942; M.A., George Washington, 1962; Ph.D., Lehigh, 1974.

Robert Pey-Ying Wei (1966, 1970)
Professor of Mechanics
B.S., Princeton, 1953; M.S., 1954; Ph.D., 1960.

Daniel Jacob Roger Weine (1972)
Social Science Cataloger
B.A., Vermont, 1961; M.A.T., Harvard, 1962; A.M.L.S., Michigan, 1967.

Leonard Andrew Wenzel (1951, 1962)
Professor and Chairman of Chemical Engineering
B.S., Penn State, 1943; M.S., Michigan, 1948; Ph.D., 1950. P.E., Pennsylvania, 1958.

Nils H. Wessell (1972)
Visiting Assistant Professor of Government
A.B., Stanford, 1964; M.A., 1970; Ph.D., Columbia, 1972.

Donald Bigham Wheeler, Jr. (1947, 1957)
Associate Professor of Physics
B.S., Lehigh, 1938; Ph.D., Cal Tech, 1947.

Howard R. Whitcomb (1967)
Assistant Professor of Government
A.B., Brown, 1961; M.A., Lehigh, 1963; Ph.D., 1971.

John Calvin Whitehead (1967)
Instructor in Physical Education and Assistant Varsity Football Coach
B.S., East Stroudsburg State, 1950.

Gary E. Whitehouse (1965, 1974)
Professor of Industrial Engineering
B.S., Lehigh, 1960; M.S., 1962; Ph.D., Arizona State, 1966.
P.E., Pennsylvania, 1966.

Joseph Hardy Whritenour (1965)
Assistant Director of Public Information

Albert Wilansky (1948, 1957)
Professor of Mathematics
B.A., Dalhousie (Canada), 1941; B.S., 1942; Ph.D., Brown, 1947.

Robert Clifford Williamson (1963, 1964)
Professor of Sociology and Chairman of Social Relations
B.A., U.C.L.A., 1938; M.A., 1940; Ph.D., Southern California, 1951.

Gregory B. Wilson (1972)
Staff Assistant, Aerospace Studies
Staff Sergeant, U.S.A.F.

Kenneth E. Wolf (1966)
Adjunct Professor of Biology
B.S., Utah, 1951; M.S., 1951; Ph.D., 1956.

John Dudley Wood (1960, 1965)
Associate Professor of Metallurgy and Materials Science
B.S., Case-Western Reserve, 1953; M.S., Lehigh, 1959; Ph.D., 1962.

Robert L. Wright
Supervisor, Department of Building and Grounds

Raymond F. Wylie (1973)
Instructor in International Relations
B.A., Toronto, 1964; M.A., 1968.

Ellen J. Yamaguchi (1973)
Administrative Assistant, Residence
B.A., Beaver, 1972.

Diane Yanis (1971)
Assistant to the Director, Public Information
B.S., Syracuse, 1970.

Willard Ross Yates (1955, 1963)
Professor of Government
B.A., Oregon, 1948; M.A., 1949; Ph.D., Yale, 1956.

Kenneth M. Yeisley
Assistant Superintendent, Buildings and Grounds.

Bung-Tseng Yen (1957, 1968)
Associate Professor of Civil Engineering
B.S., National Taiwan, 1955; M.S., Lehigh, 1959; Ph.D., 1963.

Thomas Edwin Young (1958, 1966)
Professor of Chemistry
B.S., Lehigh, 1949; M.S., 1950; Ph.D., Illinois, 1952.

Gregory A. Zebrowski (1972)
Instructor in Education
B.S., East Stroudsburg, 1971.

Daniel Zeroka (1967, 1974)
Associate Professor of Chemistry
B.S., Wilkes, 1963; Ph.D., Penn, 1966.

Albert Charles Zettlemoyer (1941, 1969)
Provost and Vice President, and Distinguished Professor of Chemistry
B.S., Lehigh, 1936; M.S., 1938; Ph.D., M.I.T., 1941; D.Sc., Clarkson, 1965; LL.D., The China Academy, 1974.

Vincent Ziccardi (1974)
Assistant Professor of Aerospace Studies
B.S., Rider, 1962; M.B.A., Southwest Texas State, 1974.
Captain, U.S.A.F.

Emory W. Zimmers, Jr. (1969, 1973)
Instructor in Industrial Engineering
B.S., Lehigh, 1966; B.S., 1967; M.S., 1967.

Emeriti

The first year given is the year in which the person commenced employment with Lehigh University. In some cases, individuals left and returned, so that an additional date is given. The final date in all cases is the year in which the person achieved emeritus status.

Carl Elmer Allen (1930, 1964)
Professor Emeritus of Accounting
B.S., Illinois, 1923; M.S., 1925; Ph.D., 1930. C.P.A., Pennsylvania, 1939.

Edward Delbert Amstutz (1938, 1972)
Howard S. Bunn Distinguished Professor Emeritus of Chemistry
B.S., Wooster, 1930; M.S., Institute of Paper Chemistry, 1932; Ph.D., Cornell, 1936; D.Sc., Wooster, 1969.

Lloyd William Ashby (1966, 1971)
Professor Emeritus of Education
A.B., Hastings (Nebraska), 1927; M.A., Columbia Teachers College, 1935; Ed.D., 1950.

Allen Jennings Barthold (1939, 1967)
Professor Emeritus of Romance Languages
B.A., Lehigh, 1921; Ph.D., Yale, 1931.

Jacob Lynford Beaver (1917, 1952)
Professor Emeritus of Electrical Engineering
E.E., Lehigh, 1904; M.S., 1921; Sc.D., Harvard, 1932.

Lois Reed Benson (1955, 1971)
Chief Nurse and Administrative Assistant Emeritus, Health Service
B.A., Michigan, 1932; R.N., Allentown Hospital, 1939.

Robert Dominick Billinger (1923, 1965)
Associate Professor Emeritus of Chemistry
B.S., Lehigh, 1921; M.S., 1925; Ph.D., Cincinnati, 1929.

Charles Wilfred Brennan (1955, 1974)
Dean of Students Emeritus and Professor Emeritus of Industrial Engineering
B.S., Alabama, 1934; M.B.A., 1953.

Natt Bryant Burbank (1964, 1971)
Professor and Assistant Dean Emeritus, School of Education
A.B., Vermont, 1925; M.A., Columbia, 1931; LL.D., Vermont, 1963.

Allison Butts (1957, 1961)
Professor Emeritus of Metallurgy and Materials Science
A.B., Princeton, 1911; B.S., M.I.T., 1913.

Clarence Bowen Campbell (1947, 1957, 1974)
Dean of Residence Emeritus
B.A., Temple, 1937; M.A., Lehigh, 1947.

Cloyd Criswell (1947, 1973)
Associate Professor Emeritus of English
B.S., in Ed., Millersville State, 1933; M.A., New York, 1937.

Cassius Wild Curtis (1946, 1971)
Professor Emeritus of Physics
A.B., Williams, 1928; Ph.D., Princeton, 1936.

Edward Hutchins Cutler (1930, 1947)
Associate Professor Emeritus of Mathematics
A.B., Harvard, 1925; A.M., 1926; Ph.D., 1930.

H. Barrett Davis (1946, 1972)
Professor Emeritus of Speech
B.L.I., Emerson, 1929; Cert., American Academy of Dramatic Arts, 1930; M.A. (Hon.), Emerson, 1958.

Warren M. Davis (1971, 1974)
Associate Professor Emeritus of Education
A.B., Ohio, 1933; M.A., Ohio State, 1939; Ph.D., 1952.

Albert William de Neufville (1948, 1957)
Associate Professor Emeritus of Mechanics
Dipl. Ing., Berlin, 1922; M.S., Stevens Institute, 1948; Ph.D., Lehigh, 1952.

Herbert Maynard Diamond (1927, 1964)
Professor Emeritus of Economics
B.A., Yale, 1914; Ph.D., 1917.

Aurie Nichols Dunlap (1948, 1973)
Professor Emeritus of International Relations
A.B., Union (New York), 1929; A.M., Columbia, 1931; Ph.D., 1955.

William Joseph Eney (1936, 1971)
Joseph T. Stuart Professor Emeritus of Civil Engineering
B.S., Johns Hopkins, 1927; M.S., Lehigh, 1938. P.E., Pennsylvania, 1939.

James Van Deusen Eppes (1950, 1974)
Professor Emeritus of Mechanical Engineering
B.A., Virginia, 1928; M.E., Cornell, 1931; M.S. in M.E., Lehigh, 1943.

George Dormer Farne (1927, 1945)
Assistant Professor Emeritus of Romance Languages
A.B., Columbia, 1926; M.A., 1927.

Adelbert Ford (1931, 1955)
Professor Emeritus of Psychology
A.B., Michigan, 1920; A.M., 1923; Ph.D., 1926.

George Dewey Harmon (1925, 1964)
Professor Emeritus of American History
B.A., Duke, 1921; M.A., 1922; Ph.D., Penn, 1930.

Robert Austin Harrier (1951, 1970)
Executive Secretary Emeritus, Alumni Association
E.M., Lehigh, 1927.

Ladd E. Hoover (1960, 1967)
Associate Director Emeritus of the University Health Service
B.Sc., University of Nebraska College of Medicine, 1924; M.D., 1926.

Voris V. Latshaw (1931, 1947)
Associate Professor Emeritus of Mathematics
B.A., Indiana, 1927; A.M., 1928; Ph.D., 1930.

John Douglas Leith (1945, 1964, 1966)
Dean Emeritus of Students
A.B., North Dakota, 1920; A.M., Columbia, 1924.

Ethel May McCormick (1964, 1969)
Associate Professor Emeritus of Education
B.S., Northwestern, 1931; M.Ed., Penn State, 1941; D.Sc.Ed., Cedar Crest, 1963.

George Walter McCoy, Jr. (1956, 1970)
University Physician Emeritus
B.S., Pennsylvania, 1929; M.D., 1932.

Archie Roscoe Miller (1922, 1961)
Professor Emeritus of Electrical Engineering
B.S., Illinois, 1918; M.S., Lehigh, 1925.

Albert Charles Molter (1960, 1974)
Purchasing Agent Emeritus
B.S., Norwich, 1928.

Harvey Alexander Neville (1927, 1964)
President Emeritus
A.B., Randolph-Macon, 1918; M.A., Princeton, 1920; Ph.D., 1921; LL.D. (Hon.), Randolph-Macon, 1952; L.H.D. (Hon.), Moravian, 1962; LL.D. (Hon.), Lafayette, 1962; Sc.D. (Hon.), Lehigh, 1965.

Basil Waldo Parker (1940, 1974)
Professor Emeritus of Biology
S.B., M.I.T., 1933; A.M., Harvard, 1935; Ph.D., M.I.T., 1939.

Howard Charles Pieper (1967, 1973)
University Physician Emeritus
B.S., Iowa State, 1926; M.D., 1932.

George Emil Raynor (1931, 1964)
Professor Emeritus of Mathematics
B.S., Washington, 1918; M.A., Princeton, 1920; Ph.D., 1923.

Joseph Benson Reynolds (1907, 1948)
Professor Emeritus of Mathematics and Theoretical Mechanics
B.A., Lehigh, 1907; M.A., 1910; Ph.D., Moravian, 1919.

Edgar Heisler Riley (1926, 1958)
Associate Professor Emeritus of English
A.B., Cornell, 1915; Ph.D., 1925.

Raymond Burkert Sawyer (1946, 1964)
Associate Professor Emeritus of Physics
Ph.B., Ripon, 1921; M.S., Wisconsin, 1925; Ph.D., Chicago, 1930.

Ernst Bernhard Schulz (1927, 1965)
Professor Emeritus of Political Science
B.S., Michigan, 1920; M.A., 1921; Ph.D., 1927.

Charles Augustus Seidle (1948, 1970)
Vice President Emeritus
B.A., Pittsburgh, 1931; M.A., Columbia, 1936; Ed.D., 1948.

Edith Amanda Seifert (1923, 1969)
Bursar Emeritus

Jonathan Burke Severs (1927, 1969)
Distinguished Professor Emeritus of English
A.B., Rutgers, 1925; A.M., Princeton, 1927; Ph.D., Yale, 1935. F.R.S.A., 1962.

Earl Kenneth Smiley (1934, 1964)
Vice President Emeritus
A.B., Bowdoin, 1921; M.A., Lehigh, 1935; L.H.D. (Hon.), Moravian, 1947; LL.D., (Hon.), Waynesburg, 1952.

Judson Gray Smull (1919, 1950)
Associate Professor Emeritus of Chemistry
B.S., Lehigh, 1906; M.S., 1921.

Wilbur Devilla Bernhart Spatz (1946, 1973)
Professor Emeritus of Physics
B.S., Lafayette, 1930; M.S., Purdue, 1934; Ph.D., New York, 1943.

Carl Ferdinand Strauch (1934, 1974)
Distinguished Professor Emeritus of English
A.B., Muhlenberg, 1930; M.A., Lehigh, 1934; Ph.D., Yale, 1946.

Milton Caleb Stuart (1926, 1952)
Professor Emeritus of Mechanical Engineering
B.S., Penn, 1909; M.E., 1924.

Merle W. Tate (1965, 1974)
Professor Emeritus of Education
A.B., Central Wesleyan, 1926; M.A., Montana, 1943; Ed.M., Harvard, 1946; Ed.D., 1947.

Francis John Trembley (1928, 1972)
Professor Emeritus of Ecology
B.S., Hobart, 1928; M.S., Lehigh, 1931; Ph.D., Penn, 1934; D.Sc., Hobart, 1964.

John Schrader Tremper (1939, 1968)
Associate Professor Emeritus of German
A.B., Colgate, 1928; M.A., Cornell, 1932; Ph.D., 1938.

Wendell Piggott Trumbull (1957, 1974)
Professor Emeritus of Accounting
B.S., Illinois, 1937; M.A., Michigan, 1941; Ph.D., 1954.
C.P.A., Mississippi, 1949.

John Harms Ubben (1960, 1973)
Professor Emeritus of German
A.B., Central College (Iowa), 1936; M.A., Kentucky, 1937; Ph.D., Chicago, 1942.

Ralph Newcomb vanArnam (1928, 1967)
Associate Professor Emeritus of Mathematics and Astronomy
E.E., Cornell, 1926; M.S., 1927.

Lawrence Whitcomb (1930, 1965)
Associate Professor Emeritus of Geology
Ph.B., Brown, 1922; A.M., Princeton, 1928; Ph.D., 1930.

Ralph Charles Wood (1958, 1961)
Professor Emeritus of German
B.A., and B.E., Cincinnati, 1928; M.A., 1930; Ph.D., Cornell, 1933.

Prizes and Awards

Student prizes and awards are announced at commencement exercises on Founder's Day, the second Sunday in October, and on University Day in May or June. A description of prizes and awards follows.

Alumni Prizes. Funds are provided by the Alumni Association for the annual award of four prizes of $25 each. Two prizes are awarded to the highest-ranking juniors in the College of Engineering and Physical Sciences, one to the highest-ranking junior in the College of Arts and Science, and one to the highest-ranking junior in the College of Business and Economics.

Medal of the Philadelphia Chapter, American Institute of Chemists. This medal is awarded to the academically highest-ranking senior majoring in chemistry or chemical engineering.

American Society for Testing Materials Student Membership Prize. The ASTM awards each year four student memberships to students who in their junior year have demonstrated interest and meritorious work in the engineering courses which are related to the American Society for Testing Materials.

Bethlehem Fabricators Award. This tuition award is made to the senior who has shown the most improvement in academic achievement over previous years.

The Robert W. Blake Memorial Prize. This prize is awarded annually at the Founder's Day exercises to a freshman, upon completion of one year of studies in the College of Arts and Science, who is recommended by the college faculty as the most outstanding in high scholastic achievement and in promise of worthy leadership.

The John B. Carson Prize. An annual prize of $50 was established by Mrs. Helen Carson Turner, of Philadelphia, in memory of her father, John B. Carson, whose son, James D. Carson, was a graduate of the civil engineering curriculum in 1876. It is awarded to the senior in civil engineering who shows the most marked excellence in professional courses.

The William H. Chandler Prizes in Chemistry. Four annual prizes of $25 each, one in each class, for excellence in the chemistry and chemical engineering curricula were established by Mrs. Mary E. Chandler, of Bethlehem, widow of Dr. William H. Chandler, who was professor of chemistry at Lehigh from 1871 until his death in 1906.

The N. I. Stotz and D. E. Pickert Choral Cup. The choral cup provided by Norman I. Stotz, Jr., '53, and Donald E. Pickert, '53, is awarded to the outstanding senior participating in the choral organizations of the music department.

Class of 1904 Scholarship Award. To an outstanding member of the junior class on the basis of character, scholarship, qualifications indicating promise of future leadership, and extracurricular activities.

The R. K. Burr and J. D. Kirkpatrick Concert Cup. The concert cup provided by Richard K. Burr, '53, and J. Donald Kirkpatrick, '55, is awarded to the outstanding senior(s) participating in the instrumental organizations of the music department.

The Cornelius Prize. The Cornelius Prize of $25, established by William A. Cornelius, M.S. '89, and endowed by a bequest by his widow, Mrs. Eleanor R. W. Cornelius, is awarded annually to the senior student in mechanical engineering who is judged to have profited most by opportunities at Lehigh. The award is based 70 percent on scholarship, 20 percent on attainment in general culture, and 10 percent on development in personality. To be eligible for the award, a student's scholastic standing must be in the top quar-

ter of the class in the College of Engineering and Physical Sciences.

The Philip Francis du Pont Memorial Prize in Electrical Engineering. The Philip F. du Pont Memorial Prize Fund was established in 1929 by L. S. Horner, E.E. '98. The annual income of this fund is awarded each year in the way of prizes, two-thirds to the highest-ranking senior and one-third to the second-highest-ranking in electrical engineering.

Fraternity Alumni Advisory Council Scholarship Improvement Award. This trophy is awarded to the fraternity chapter whose scholastic average for the year is most improved over the average for the previous year.

The Gold-Hansen Trophy. Provided by Stephen R. Gold and Robert A. Hansen, both members of the class of 1960, the trophy is awarded to a student of at least four semesters' standing with the Lehigh University Band who has shown outstanding merit in other ways than musical or marching performance.

Malcolm J. Gordon, Jr. Physics Prize. An annual award of $40 is made to the highest-ranking sophomore majoring in physics with some extracurricular activity.

The Bill Hardy Memorial Prize. An annual award of $100 is given by Mr. and Mrs. C. Edson Hardy in memory of their son to the junior who most nearly reflects the qualities that typified Bill Hardy, who was outstanding in many activities, academic and otherwise.

Haskins and Sells Foundation Award. An annual award of $500 is awarded to that accounting student in the College of Business and Economics or the College of Arts and Science who after three years has demonstrated excellence in scholarship, professional potential, extracurricular activities, and moral character.

The Harold J. Horn Prize. The heirs of Harold J. Horn, E.E. '98, established a fund, the income of which is used in the award of a first and second prize of $40 and $20 respectively for the two highest-ranking juniors in electrical engineering.

Kappa Alpha Glee Club Senior Cup. To a senior for outstanding service to the Lehigh University Glee Club.

The Andrew Wilson Knecht III Memorial Award. This award is made each year to the member of the mechanical engineering class graduating in May or June who has exhibited the greatest potential for applying technical training to practical application. The award is an engraved designed medallion.

The McClain Award for Meritorious Painting. This award, consisting of a trophy and a fifteen dollar purchase prize, and provided by Austin V. McClain, is presented to the student of painting in the fine arts department studio classes who completes the most meritorious painting during the academic year.

The McClain Progress Award. This award, consisting of a trophy and a $15 purchase prize, provided by Austin V. McClain, is presented to that student whose progress in painting in the fine arts department studio classes during the year is most marked.

Merck Index Award. A copy of the *Merck Index* is awarded by Merck and Co., Inc., to a senior in chemistry who is an outstanding student, who has been active in student society affairs and who has promise of a successful career in chemistry in the judgment of the faculty of the chemistry department.

The Elizabeth Major Nevius Award. Established by Walter I. Nevius, E.E., '12, "in living memory of his wife, who profoundly admired young men of diligence, intelligence, aggressiveness and sterling character," the award of $500 is made annually to that senior enrolled in any five-year combination curriculum leading to two baccalaureate degrees who, upon completion of his or her first four years at Lehigh University and upon graduation with his or her class, shall be adjudged the most outstanding of the seniors completing work for their first baccalaureate degree and continuing to a second baccalaureate degree at Lehigh University, judged upon the basis of leadership, citizenship, and scholarship.

Pat Pazzetti Award. In honor of Vincent Joseph "Pat" Pazzetti, Jr., class of 1915, to a Lehigh football player of outstanding ability.

The Pennsylvania Institute of Certified Public Accountants Prize. This plaque goes to the senior in the College of Business and Economics majoring in accounting who is outstanding in academic achievement and leadership.

Phi Sigma Kappa Scholarship Cup. This scholarship cup, awarded to the fraternity in the Interfraternity Council having the highest scholastic average for the preceding year, becomes the permanent property of the fraternity winning it for three successive years. The cup was provided by an alumnus of the Nu Chapter of Phi Sigma Kappa in 1923. Cups are provided by the local chapter.

The Allen S. Quier Prize in Metallurgy. An annual prize of $15 has been provided by the daughters of the late Allen S. Quier in memory of their father, to be awarded to the senior who is adjudged by the staff of the metallurgy and materials science department to have made the most progress in that curriculum. While high scholastic standing is a requisite, the prize is awarded on the basis of progressive achievement in scholastic work, rather than an average rating.

Bosey Reiter Leadership Cup. This award is given to the student whose leadership contributes primarily to the best interests of the university. Leadership is defined chiefly as moral character and combines intellectual ability and common sense. High scholarship and athletic achievements are included as cases of leadership, but neither is necessary or sufficient alone.

Robert Ridgeway Senior Prize. This prize is awarded to the engineering senior with the highest cumulative average.

Col. Edward W. Rosenbaum Award. The award, in honor of Robert Rosenbaum, class of 1917, is awarded each year to recognize the outstanding senior aerospace studies student.

The Senior Band Plaque. The plaque was established by the seniors on the executive committee of the Lehigh University Band to honor a member or members of the senior class of the band who have given outstanding performances in both marching and concert seasons for four years and who have not served in a major administrative capacity in the band.

The T. Edgar Shields Cups. These cups were established by the late Dr. T. Edgar Shields, former director of music at Lehigh. They are awarded annually to the students who are considered most outstanding in vocal and instrumental activities.

Sigma Xi Undergraduate Research Award. An award of $50 and associate membership in the society is made to an undergraduate student by the chapter executive committee from departmental nominations. The basis of the award is research potential and demonstrated achievement in research.

Spillman and Farmer Architectural Award. An architectural book and $15 is awarded to the student(s) creating the outstanding architectural or environmental design in the architecture classes of the fine arts department.

Bradley Stoughton Student Award. This award is given to an outstanding senior in the metallurgy and materials science department. It consists of a certificate and $25.

Thornburg Mathematics Prize. This prize is made possible through a bequest by the late W. P. Tunstall, '03, in honor of the late Professor Charles L. Thornburg. The prize, consisting of a credit slip for $40 to purchase books in the field of mathematics or allied disciplines at the Bookstore, is awarded to the senior with the most outstanding record in an advanced course in mathematics.

Trustees' Scholarship Cup. The trustees have provided this cup which is awarded for one year to the living group having the highest scholarship average for the preceding year. The cup becomes the permanent property of any living group winning it for three successive years.

University Service Award. This award is given annually to the senior who has been adjudged to have contributed most during his or her career at Lehigh, to promote student body unity, campus cooperation for worthy objectives, and loyalty to the alma mater. It is expected that the student selected shall be of sound character and satisfactory scholarship.

William Whigham, Jr. Memorial Prize. This is awarded annually to the top-ranking freshman in engineering,

based on accumulative average of the first two semesters.

The Elisha P. Wilbur Prizes. A fund was established by the late E. P. Wilbur, trustee from 1872 until 1910, for distribution in prizes as the faculty might determine. The income from this fund is used to provide two awards, as follows:

Wilbur Mathematics Prizes. A first and second prize of $50 and $25 respectively to be awarded annually to the two highest-ranking freshman engineers in mathematics, as recommended by the department of mathematics.

Wilbur Scholarship Prize. This prize of $200 is awarded annually to the sophomore with the best semester average for the sophomore year.

The Williams Prizes in English. The late Professor Edward H. Williams, Jr., Class of 1875, established prizes for excellence in English composition and public speaking. The prizes are awarded by the faculty on the recommendation of the department of English, as follows:

Freshman Composition Prizes. A first prize of $100, a second prize of $75, and a third prize of $50 are awarded for the three best compositions submitted by freshmen as required work in their English courses.

Sophomore Composition Prizes. A first prize of $100, a second prize of $75, and a third prize of $50 are awarded for the three best compositions submitted by sophomores as required work in their English courses.

Junior Composition Prizes. A first prize of $100, a second prize of $75, and a third prize of $50 are awarded for the three best essays submitted by juniors as part of the required work in their courses in English.

The Williams Prizes in Extempore Speaking. A first prize of $100 and a second prize of $50 are awarded annually to freshmen of regular standing who excel in a contest in extempore speaking. A first prize of $100, a second prize of $75, and a third prize of $50 are awarded annually to the winners in a contest in extempore speaking for sophomores, juniors and seniors. Winners of first prizes are not eligible to compete in subsequent years.

The Williams Prizes in Intramural Debating. Sums totaling $300 are awarded annually as prizes in intramural debating. Students engaged in this activity are organized under the direction of the department of English into teams which compete in a series of debates. The sum of $200 is divided equally between the two members of the first-place team and the sum of $100 is divided equally between the two members of the second-place team. Winners of first-place prizes are not eligible to compete in subsequent years.

The Williams Prize in Dramatics. A prize of $100 is awarded annually to a Lehigh undergraduate whose interpretation of a role in a production of the Mustard and Cheese dramatics club is judged the most outstanding.

The Williams Prize in Interpretive Reporting. A prize of $100 is awarded annually to a Lehigh undergraduate for meritorious reporting, published or unpublished, intended to interpret the meaning of events or developments which are significant in the life of the university.

The Williams Prize in Creative Writing. A prize of $100 is awarded annually to the author of a meritorious short story, play, or poem submitted by a Lehigh undergraduate.

The Williams Prize in Varsity Debating. A prize of $100 is awarded annually to a Lehigh undergraduate whose performance in intercollegiate debating is judged the most outstanding.

The Williams Senior Prizes. These prizes are awarded by the faculty on the recommendation of the committee on Williams Prizes.

1. First prizes of $200, second prizes of $100, and third prizes of $50 are awarded annually in each of the five fields of economics, English, philosophy, psychology, and history and government for dissertations submitted by regular members of the senior class on or before April 15.

2. The committee on Williams Prizes publishes, before the close of the academic year, a list of recommended subjects for dissertations; but a senior may submit a dissertation upon any other subject in the respective field if the subject has received the approval of the committee.

3. Each senior entering the competition shall submit to the committee his or her choice of subject and plan of work by November 15.

4. The awards are made by the faculty upon recommendation of the committee, but no award is made if in any case a dissertation does not meet the standards of merit established by the committee. This standard includes such points as excellence in thought, plan, development, argument, and composition.

The Theodore B. Wood Prize. A prize of $50 is awarded under the terms of the will of the late Theodore Wood to the mechanical engineering student who has made the greatest scholastic improvement during the first two years of the college course.

Prizes awarded by student organizations. These prizes include the following:

Alpha A. Diefenderfer Award. In recognition of Professor A. A. Diefenderfer's long service as faculty advisor to the organization, the Lehigh University Chemical Society established this award for the highest-ranking senior in analytical chemistry. Each winner is presented with an engraved certificate, and the name is inscribed on a plaque displayed in the chemistry building.

Alpha Epsilon Delta Award. Alpha Epsilon Delta places the name of the premedical biology freshman with the highest cumulative average on a plaque in the department of biology.

Alpha Kappa Psi Key. The Alpha Sigma Chapter of Alpha Kappa Psi, a professional fraternity in commerce, awards annually the Alpha Kappa Psi scholarship key to the senior pursuing a degree in the College of Business and Economics who has attained the highest scholastic average for three years of collegiate work at Lehigh.

The Alpha Pi Mu Prize. The Alpha Pi Mu honorary fraternity in industrial engineering awards each year an industrial engineers' handbook to a high-ranking sophomore with demonstrated interest in the industrial engineering curriculum.

American Chemical Society Award. The Lehigh Valley Section of the American Chemical Society awards a membership in the society and a subscription to a journal of this society to the highest-ranking junior in chemistry or chemical engineering.

American Society of Civil Engineers Prize. The Lehigh Valley Section of the American Society of Civil Engineers offers a prize of a junior membership in the society to the outstanding senior in civil engineering holding membership in the student chapter.

American Society of Mechanical Engineers Associate Membership Prize. The Anthracite-Lehigh Valley Section of the American Society of Mechanical Engineers awards a prize of the value of $10 to an outstanding member of the Lehigh student branch of the ASME. This prize takes the form of associate membership for one year in the parent society.

Eta Kappa Nu Prize. The honorary fraternity in electrical engineering awards a handbook in electrical engineering to the highest-ranking freshman in electrical engineering.

Phi Eta Sigma Award. The Lehigh chapter of this national freshman honor society offers an award to the residence halls section with the highest freshman average for the fall semester each year. The trophy is a gift of the late Professor Harold V. Anderson of the chemistry department.

Pi Lambda Phi Journalism Award. This is awarded to an undergraduate for outstanding editorial or business achievement in the field of publications. The trophies are made available by the local chapter of Pi Lambda Phi fraternity.

Pi Tau Sigma Prize. The honorary fraternity in mechanical engineering awards each year a mechanical engineers' handbook to the highest-ranking sophomore in mechanical engineering.

William H. Schenpf Award. This award is made annually to the freshman who has shown outstanding ability and interest beyond the requirements of a normal freshman bandsman. It is made in honor of a former head of the music department by the Beta Sigma chapter of Theta Chi fraternity.

Tau Beta Pi Prize. The honorary engineering fraternity awards each year a slide rule or other prize of equivalent value to the engineering sophomore having the highest scholastic average.

Finding Your Way Around

The accompanying map shows the university's 200-acre South Mountain campus. Please note that south is at the top of the map, reversing the customary practice of cartographers. In general, classroom buildings are located in the lower portion of the campus, with residential facilities and other structures located higher up the mountainside. Visitors may want to travel to the Lookout at the easternmost point of the campus (location G-6), which affords a dramatic view of the entire Lehigh Valley.

University Buildings

27	Alumni Memorial Building (admission and administration) 0-10
3	Buildings and Grounds Office G-12
4	Center for the Application of Mathematics G-12
10	Central Heating and Refrigeration F-12
17	Chandler Chemistry Laboratory I-10
14	Christmas-Saucon Hall J-12
9	College of Arts and Science (Maginnes Hall) M-13
35	College of Business and Economics (Drown Hall) K-8
19	College of Engineering and Physical Sciences (Packard Laboratory) M-11
33	Coppee Hall J-9
32	Coxe Laboratory I-9
35	Drown Hall K-8
23	Education Buildings and Annex Q-11
16A	Sherman Fairchild Laboratory for Solid State Studies (completion 1976) H-10
2	Figlear Building, Center for the Application of Mathematics L-15
103	Firehouse facility N-6
13	Fritz Engineering Laboratory I-11
11	Fritz Laboratory Office Annex H-12
39	Grace Hall G-9
36	Health Services Building L-8
34	Lamberton Hall J-8
30	Linderman Library J-9
9	Maginnes Hall M-13
8	Mart Science and Engineering Library K-13
6, 6A	Seeley G. Mudd Chemistry Complex I-12
19	Packard Laboratory M-11
18	Packer Memorial Church K-11
15	Philosophy Building L-12
16	Physics Building G-11
28	President's House N-9
40	Price Hall G-8
108	Sayre Park comfort station E-3
26	Sayre Psychology Laboratory P-10
7	Sinclair Laboratory J-13
38	Taylor Gymnasium F-10
37	Taylor Stadium
24	Town House Q-10
29	University Center (Packer Hall) L-9
5	Whitaker Metallurgical and Chemical Engineering Laboratory I-13
12	Wilbur Power House (renovation 1975, to become drama facility) G-11
31	Williams Hall H-10

Residence Halls

55	Beardslee House C-10
	Bishopthorpe Residence, Tombler St. and Jeter Ave.
54	Carothers House C-10
56-62	Centennial I Houses D-8
50-55	Centennial II Houses B-9
58	Commons area D-9
56	Congdon House C-9
65	Dravo House H-7
64	Drinker House I-7
57	Emery House D-9
62	Leavitt House D-8
67	McClintic-Marshall House L-7
61	McConn House E-8
53	Palmer House C-10
63	Rathbone Dining Hall (Residence Halls offices on lower level) D-9
70	Residence Halls (RH-11) buildings A through G N-9
66	Richards House G-8
59	Smiley House E-9
52	Stevens House C-10
51	Stoughton House B-10
68	Taylor House M-7
60	Thornburg House E-9
50	Williams House B-10

Fraternities

93	Alpha Chi Rho O-4
106	Alpha Sigma Phi N-5
99	Alpha Tau Omega I-5
83	Beta Theta Pi N-6
105	Chi Phi O-5
84	Chi Psi P-6
21	Delta Chi, 233 W. Packer Ave. T-12
22	Delta Chi Annex, 230 W. Packer Ave. S-11
86	Delta Phi R-6
20	Delta Sigma Phi, 217 W. Packer Ave. S-11
89	Delta Tau Delta Q-6
81	Delta Upsilon Q-7
85	Kappa Alpha R-7
87	Kappa Sigma T-5
97	Lambda Chi Alpha L-4
101	Phi Delta Theta L-6
104	Phi Gamma Delta N-6
88	Phi Kappa Theta S-5

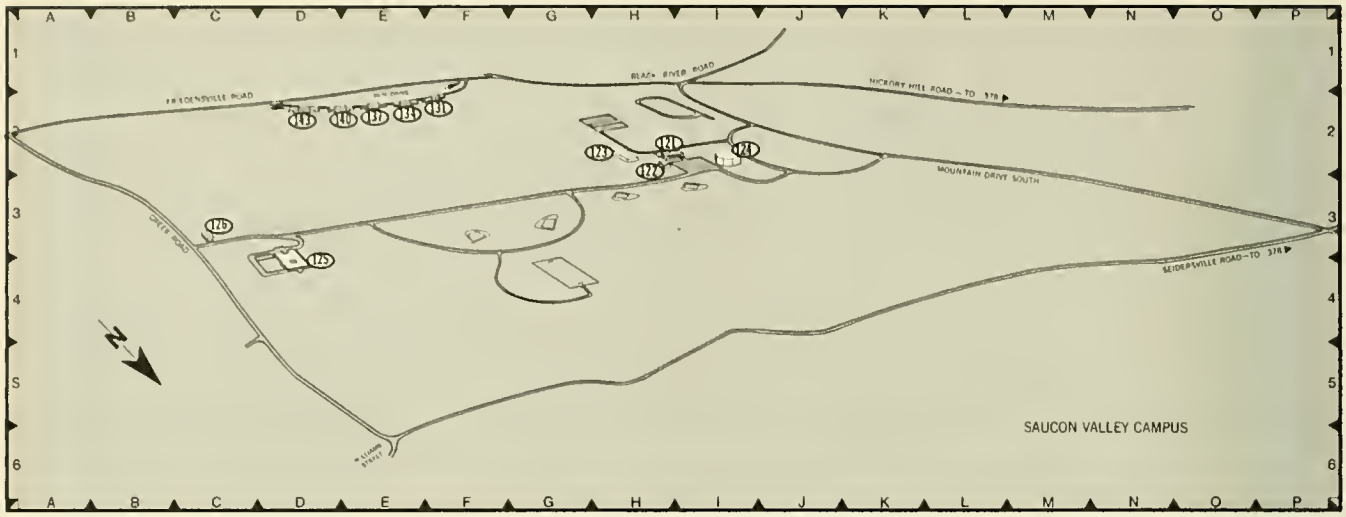
90	Phi Sigma Kappa P-5 Pi Kappa Alpha, 515 Delaware Ave.
98	Pi Lambda Phi K-4
80	Psi Upsilon R-8
94	Sigma Alpha Mu Q-3
102	Sigma Chi M-6
82	Sigma Nu O-7
100	Sigma Phi L-7
92	Sigma Phi Epsilon R-5
25	Tau Epsilon Phi, 227-229 Warren Square S-11
91	Theta Chi Q-4
107	Theta Delta Chi K-5
96	Theta Xi M-4
95	Zeta Psi K-4

The University Green located at the Flagpole (location L-10) is the site of numerous student events and awards presentation ceremonies.

Memorial Drive, just above buildings 16A and 17, locations H-10 and I-10, will remain closed indefinitely due to construction work on the Sherman Fairchild Laboratory for Solid State Studies (16A).

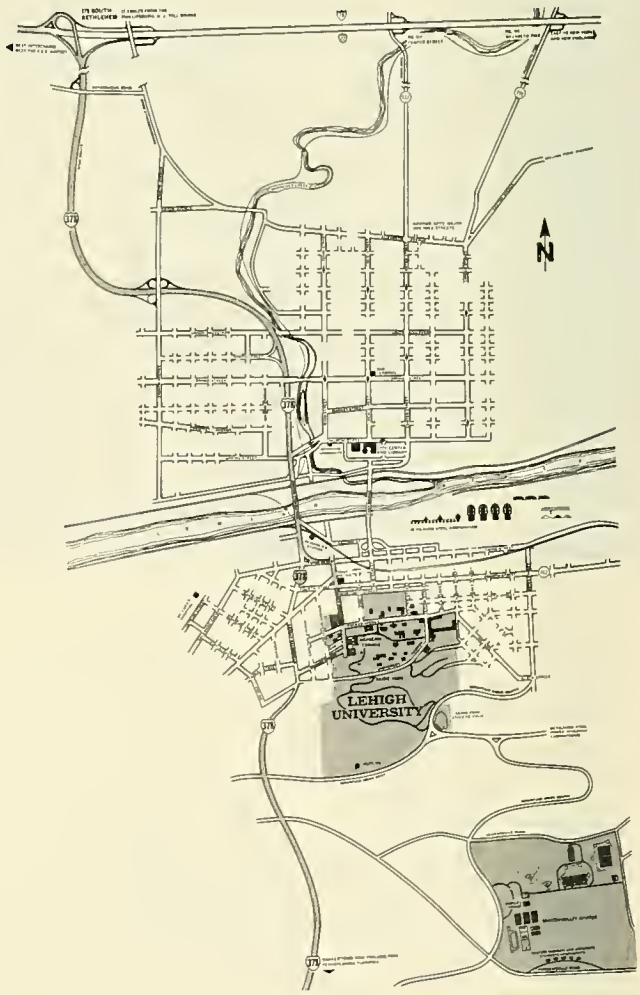
The parking facility indicated at the east end of Taylor Stadium (37) is scheduled for construction during the summer of 1975.

The Sayre Park residential area is closed to vehicular traffic during summers and vacation periods.



Saucon Valley Campus

121	Varsity House
122	Squash Court Building
123	Field House (completion 1975)
124	Athletic and Convocation Center (proposed)
125	Centennial School
126	Butler Building
131-143	Saucon Married and Graduate Students residences (SMAGS)
131	Severs
134	More
137	Hartman
140	Gipson
143	Diamond



The map at the right shows the main Lehigh University campus in relation to the City of Bethlehem. Unlike the campus maps shown, north is at the top. Routes to the university are indicated.

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Lehigh

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