1973-1975

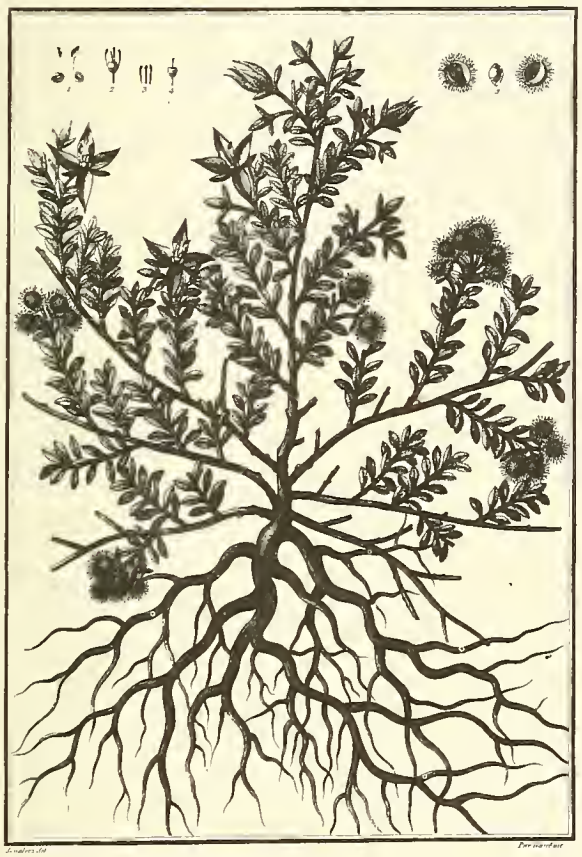
University Catalog of Curricula,
Courses and Degree Requirements

Lehigh

Lehigh

University Catalog of Curricula, Courses and Degree Requirements

1973-1975



The Lehigh University Catalog is published biennially. The next edition will be published in April, 1975. 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 necessary. Lehigh is published four times annually during the calendar year by Lehigh University, Bethlehem, Pennsylvania 18015. Issues of Lehigh include the Summer Session (March), the University Catalog (April), Introduction to the University (August), and the Report of the President (October). Volume 47, Number 2, April 1973. Second class postage paid at Bethlehem, Pennsylvania 18015. Edited and designed by the Lehigh University Office of University Publications: George L. Beezer, Director; Marvin H. Simmons, Assistant Director; Lynn D. Klein, Production Assistant; Sara L. Paden, Administrative Assistant. Composition set in Aldine Roman; display type in Palatino. Printing by Holben Printing, Inc., Allentown, Pa. 40M, 3-73.

Krameria triandra, from Hippolyto Ruiz et Josepho Pavon, *Flora Peruviana et Chilensis* (1798), from the Bassler Collection, Linderman Library, Lehigh University.

The white stock used in this catalog is 60% recycled paper.

Contents

Academic Calendar

1972-1973

April 2 (Mon.)
Pre-registration begins
Last day for filing of applications for degrees to be conferred in May
April 6 (Fri.)
Pre-registration ends
April 13 (Fri.)
Last day for May Ph.D. candidates to arrange for final examinations
Last day for May Ph.D. candidates to deliver to Dean of Graduate School approved dissertation draft
April 18 (Wed.), 10 p.m.
Easter vacation begins
April 23 (Mon.), 8:10 a.m.
Easter vacation ends

May 3 (Thurs.)
Last day of classes for Arts seniors taking comprehensive examinations
Last day for submission of honors theses to thesis advisors for May graduation
May 4-8 (Fri.-Tues.)
Comprehensive examinations for Arts seniors
May 4 (Fri.)
Last day for October Ph.D. candidates to arrange for final examinations
Last day for May candidates for master's degrees to deposit with Dean of Graduate School unbound copies of theses
May 5 (Sat.)
Last day of classes in spring semester
May 7 (Mon.)
Review-Consultation-Study period begins
May 8 (Tues.)
Review-Consultation-Study period ends
Last day for May Ph.D. candidates to complete all degree requirements
May 9 (Wed.)
Course examinations begin
May 17 (Thurs.)
Course examinations end
May 27 (Sun.)
University Day

1973-1974

August 20-28 (Mon.-Tues.)
Graduate registration for fall semester
August 26 (Sun.)
Freshman check-in
August 27-28 (Mon.-Tues.)
Freshman orientation
August 29 (Wed.)
Undergraduate registration for fall semester
August 30 (Thurs.)
Fall semester instruction begins

September 4 (Tues.)
Last day for October doctoral candidates to deliver to Dean of Graduate School approved dissertation drafts
September 10 (Mon.)
Last day for filing applications for degrees to be conferred on Founder's Day
First faculty meeting
September 11 (Tues.)
Last day for October candidates for master's degrees to deposit with Dean of Graduate School unbound copies of theses
September 12 (Wed.)
Last day on which registration for fall courses will be permitted
September 28 (Fri.)
Last day for October doctoral candidates to complete all degree requirements

October 1-3 (Mon.-Wed.)
Engineering inspection trips
October 4 (Thurs.)
Tuesday classes meet
October 5 (Fri.)
Monday classes meet
October 8-9 (Mon.-Tues.)
Columbus Day holiday
October 14 (Sun.)
Founder's Day
October 29 (Mon.)
Pre-registration begins
Mid-semester reports due

November 2 (Fri.)
Pre-registration ends

November 9 (Fri.)
Last day for submission of honors theses to thesis advisors for January graduation
November 15 (Thurs.)
Last day for filing applications for degrees to be granted in January
November 16 (Fri.)
Last day for January doctoral candidates to deliver to Dean of Graduate School approved dissertation drafts
November 21 (Wed.), 10 p.m.
Thanksgiving vacation begins
November 26 (Mon.), 8:10 a.m.
Thanksgiving vacation ends
Friday classes meet
November 27 (Tues.)
Thursday classes meet

December 7 (Fri.)
Last day of classes for Arts seniors taking comprehensive examinations
Last day for January candidates for master's degrees to deposit with the Dean of Graduate School unbound copies of theses
December 10-13 (Mon.-Thurs.)
Comprehensive examinations for Arts seniors
December 11 (Tues.)
Last day of classes
December 12-13 (Wed.-Thurs.)
Review-Consultation-Study period
December 14 (Fri.)
Last day for January doctoral candidates to complete all degree requirements
Course examinations begin
December 22 (Sat.)
Course examinations end

January 2-11 (Wed.-Fri.)
Graduate registration for spring semester
January 14 (Mon.)
Undergraduate registration for spring semester
January 15 (Tues.)
Spring semester instruction begins
January 28 (Mon.)
Last day on which registration for spring courses is permitted

February 18-19 (Mon.-Tues.)
Washington's Birthday holiday
February 20 (Wed.)
Monday classes meet

March 9 (Sat.), 1 p.m.
Mid-term vacation begins
March 18 (Mon.), 8:10 a.m.
Mid-term vacation ends
Last day for filing application for degrees in May
March 21 (Thurs.)
Mid-semester reports due
March 25-29 (Mon.-Fri.)
Pre-registration

April 10 (Wed.)
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 10 (Wed.), 10 p.m.
Easter vacation begins
April 15 (Mon.), 8:10 p.m.
Easter vacation ends

May 2 (Thurs.)
Last day for classes for Arts seniors taking comprehensive examinations
Last day for submission of honors theses to thesis advisors for May graduation
May 3-7 (Fri.-Tues.)
Comprehensive examinations for Arts seniors
May 3 (Fri.)
Last day for October doctoral candidates to arrange for final examinations
Last day for May candidates for master's degrees to deposit with Dean of Graduate School unbound copies of theses
May 4 (Sat.)
Last day of classes in spring semester
May 6-7 (Mon.-Tues.)
Review-Consultation-Study period
May 8 (Wed.)
Course examinations begin
May 10 (Fri.)
Last day for May doctoral candidates to complete all degree requirements
May 16 (Thurs.)
Course examinations end
May 26 (Sun.)
University Day

Lehigh University

History and Purpose

The charter granted 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 Democratic 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 Association 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 fifty million dollars. The value of equipment, buildings, and grounds is more than sixty million dollars.

Organized as a Small University

When Lehigh opened its doors in 1866, it was given the character of a small university. The undergraduate enrollment is 3,659; the graduate enrollment 2,035. Lehigh desires to remain a small university, and with its faculty of more than 400, to provide the best possible education for a co-educational student body of its size.

Lehigh is primarily a residential university. Approximately eighty percent of the undergraduate students reside in University-operated residence halls on the campus or in the houses of national social fraternities which maintain chapters at Lehigh.

Current undergraduates come from 900 public and private secondary schools in 40 states and 26 foreign countries.

Forty-two percent of the undergraduate student body are enrolled in the College of Engineering; thirty-six percent in the College of Arts and Science; and twenty percent in the College of Business and Economics. The remaining two percent are enrolled in the five-year arts-engineering sequence.

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 lives, and opportunities to develop himself 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 create the quiet campus atmosphere. Most of the University's buildings are located on the north slope of South Mountain. An additional 500 acres in Saucon Valley, on the south side of South Mountain, are used as playing fields. With the addition of land acquired through a cooperative venture with Bethlehem's Urban Renewal program, the University has added new library, classroom, and laboratory facilities.

Settled in 1741 by Moravians seeking religious asylum, the city of 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 Choir in Lehigh's Packer Memorial Church. Situated in the center of the Lehigh Valley industrial complex, Bethlehem is preeminently a city of steel, as the home site of the main administrative offices, research laboratories, and a major production facility of the Bethlehem Steel Corporation.

There are five colleges in the Lehigh Valley besides Lehigh, all private: Lafayette (coed), Allentown College of St. Francis de Sales (coed), Moravian (coed), Muhlenberg (coed), and Cedar Crest (women). A cooperative program is maintained between the colleges and Lehigh. 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 seeks candidates without regard to race, color, religious creed, or national origin.

In the selective procedure necessitated by this 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 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.

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 his 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 the College of Engineering or the College of Business and Economics.

**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 art, classics, English, modern foreign languages, government, history, international relations, journalism, music, philosophy, social relations.

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 preparation is judged primarily by his rank or relative grade in class; by the extent to which he has made grades distinctly higher than the average grade; by evidence of improvement or deterioration in quality of record as he has progressed through secondary school; by his relative success or failure in the particular subjects which he proposes to continue in college; and by the comments and recommendations of his principal or headmaster.

Entrance Examinations

All candidates for admission to the freshman class at Lehigh University 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 aptitude and readiness for college study. Lehigh prefers that this test be written either on the November, December or the January testing date of the senior year.

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 are expected to write a Mathematics (Level I or Level II) Achievement Test. Candidates for Engineering 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 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 December, January, or March of 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 one 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 his test score be sent to Lehigh—either by indicating Lehigh on his College Board application or, if he failed to do this, by special request to the College Board office. In addition to requesting that his 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 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 9:00 a.m. and 11:00 a.m. and from 1:30 p.m. to 4:00 p.m. Interviews are also granted on Saturday mornings, but classes are not in session. Tours of the campus are available every weekday afternoon and Saturday mornings. 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 is sincerely interested in Lehigh and if he believes that he will meet admission requirements of subject matter and school record, he 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 first.

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 in the amount of $15.00. The check or money order for the application fee 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 application fee.

Early Decision

Lehigh will give a candidate an early favorable decision on his application if he meets the following criteria: (1) His preliminary credentials, including Scholastic Aptitude Test scores show clear qualification for admission to Lehigh; (2) He is certain that Lehigh is his 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 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. Lehigh encourages students to enroll in these college-level courses and to write the Advanced Placement tests offered by the C.E.E.B. each May. Entering freshmen, who ask the C.E.E.B. 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:

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 C.E.E.B. Advanced Placement Test in English. Other students who earn a score of 700 or higher on the SAT-Verbal Aptitude Test receive equal 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 by the de-

partment of mathematics of superior performance, the student receives four hours of advanced placement credit in calculus. The department also administers placement tests during Freshman Orientation to students who did not write the Advanced Placement examination and who request permission to write a Lehigh test.

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 C.E.E.B. also 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.

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

Biology. Advanced Placement and/or 3 semester hours of Lehigh credit for Biology 21 to students who earn scores of 3 or higher. Examinations are not offered during Freshman Orientation.

Physics. Advanced Placement and four semester hours of Lehigh credit for Physics 11, Introductory Physics, to students who earn scores of 4 or 5 on the Physics C examination. Placement or credit is not granted to students who write the Physics B examination. The department administers tests during Freshman Orientation to students who did not write the Advanced Placement test and who request permission to write a Lehigh examination.

Foreign Languages. The department of modern foreign languages and literatures does not normally offer advanced placement or credit based on the Advanced Placement Test. However, students scoring 600 or above on the College Board Achievement Test are exempt from the language requirement and may elect advanced language or foreign literature courses. Each language section determines student placement according to criteria which may include Achievement Test scores, Advanced Placement Test scores, years of prior study, or a personal interview.

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. In addition to the opportunities for advanced placement of freshmen, suggested in the preceding paragraphs, 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 the first of April following receipt of January College Board scores and preliminary secondary school records. Lehigh subscribes to the "Candidates' Reply Date," which has been set at May first.

When a candidate's preliminary credentials are complete and he has been offered formal admission to Lehigh University, he will be asked to notify the Director of Admission of his acceptance of the offer of admission by making a deposit of $50 to hold a place for him 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.

Presidential Prizes

Ten Presidential Prizes are awarded to entering freshmen based on merit and without regard to financial need. (See statement on page 54 of the Special

Academic Opportunities section of this catalog.)

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 his former college is not eligible for admission to Lehigh University.

A student who is planning to transfer to Lehigh University should so arrange his work in college that he will cover as many as possible of the subjects of his 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 must request each college previously attended to submit to the Office of Admission at Lehigh University an official transcript of his 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.

Tuition and Fees

Lehigh University reserves the right to change at any time the rules governing tuition and fees.

The comprehensive tuition in the undergraduate colleges is $2,850 a year. 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 $119 for each semester-hour carried, or the regular tuition, whichever amount is lower.

Undergraduate Expenses

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 $150 to $170. 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. Many elect to live in off-campus apartments or rooming houses. Students living in residence halls are required to eat in the University dining facilities. Three 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

About 50 percent of Lehigh undergraduates live in University residence halls. Lehigh has seven residence halls for undergraduate men and women. Most rooms are designed for two students, but a limited number of single, triple, and suite arrangement rooms are available. Another residence hall, comprised of apartment units, will be completed in 1974.

Room rental charges in the residence halls range from $265 to $310 per semester in 1973-74. An additional charge of $45 to $52.50 per semester is made for single rooms. Maid service 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 Office of the Dean of Residence.

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 Office of the Dean of Residence.

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, wastepaper baskets, quilts, ash trays, 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 $80 per year. Other students use coin-operated washers.

Residents will be 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 Office of the Dean of Residence.

Social Fraternities

Approximately one-third of the male students live in fraternity houses. Such accommodations are available only 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 do not move into fraternity houses until the sophomore year. Many commodities and services needed by the fraternities are provided by the co-operative 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 ex-

pense as residence (room and board) in University-operated halls.

Dining Services

Each student who lives in the residence halls is provided with board in the University dining services. The following three board plans are available:
Plan A. Twenty-one meals per week at $340 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 $307.50 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 holidays, through the last day of classes for each semester. Meals during the examination periods, ending with the noon meal of the last day of examinations are also included.
Plan C. Fifteen meals per week at $295 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 last day of classes each semester. Meals during the examination periods, ending with the noon meal of the last day of examinations, are also included.

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

The board plans and the student dining rooms are open primarily to students of the residence halls. These plans may be extended to non-residence hall students on a limited basis. In addition, a five meal per week plan is available (the noon meal, Monday through Friday) at a cost of $87.50 per semester. Students who do not live in the residence halls may apply to the Bursar for participation in one of the dining plans. A Snack Bar is operated in the University Center and is open to all students of the University.

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 illegal and will result in disciplinary action. New cards will be issued to replace lost cards upon the payment of a fee of $5.

Visitors on campus may eat in the Asa Packer Room, the faculty and guest dining room, in the University Center.

Special Fees

Military and Band Deposits. A deposit of $25 is made by each student enrolling in military or air science 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 penalty for procuring a registration ticket after the time specified by the Registrar shall be $10. A student who does not complete his registration within three days after the date of his 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 Pre-Registration Fee. The penalty for a late pre-registration or a change in pre-registration 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 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 of $119 for each such course attended.

Transcripts. Each student is entitled to one copy of his 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 involuntary induction into the armed forces, tuition will be refunded in proportion to the fraction of the semester remaining at the time of his death or induction.

If a student withdraws from the University, he is entitled to receive a refund of his 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 his total tuition less $5 for each credit hour for which he 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 his 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 10 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 students.

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 resi-

dence 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 service 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 the spring semester providing such facilities are available.

A refund shall be certified to the Bursar by the Dean of Residence.

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.

Undergraduate Scholarships and Loans

Lehigh University 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 per cent of the present undergraduate enrollment was granted University assistance. In addition, outside grants and loans were awarded to Lehigh students from programs sponsored by the Commonwealth of Pennsylvania, Army and Air Force ROTC, and many private and state sponsored organizations.

Application Procedures

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. 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 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

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 is eligible, as outlined below.

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

All upperclassmen applying for financial aid consideration may acquire their applications from the Office of Financial Aid beginning two weeks prior to the Christmas vacation. The Committee on Financial Aid reviews upperclassman 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 upperclassmen, provided that the admission and financial aid dossier is complete.

Programs Available

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 evidences 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 Annual Giving Program of Lehigh alumni. 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 parents and his own 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. The maximum indebtedness to the University that any student may normally incur will generally not exceed one-half of his total tuition obligations up to and including the semester for which he is seeking tuition aid.

Each student qualifying for a tuition loan is asked to sign a note, endorsed by his parents or guardian. Repayment schedule satisfactory to the University may be arranged through the Office of Financial Aid. Tuition loans will bear interest at the rate of 4% from the date of the note, with provision that the rates shall be increased to 6% in the case of any note which falls into default.

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 at the rate of four percent per year 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.

Every student incurring indebtedness to the University is required to undertake to pay his 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 Office of Education. These consist of the Supplementary Educational Opportunity Grant (SEOC) program, the College Work-Study Program (CW-SP), and the National Direct Student Loan (NDSL) program. All recipients are selected by the University.

SEOG is for students of exceptional financial need who without this grant would be unable to continue their education. Grants up to $1000 a year are available for 4 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 $1000 to needy students. The financial aid officer is responsible for determining eligibility. Repayment begins 9 months after graduation or termination of at least half-time study and may extend over a 10-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 3 years of service in the armed forces, Peace Corps, or VISTA. Graduate students are eligible to borrow up to $2500 per year, with deferment of previous loan repayment.

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

Guaranty loan programs exist in most states, allowing students to borrow up to $1,500 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. (See statement on page 54 of the Special Academic Opportunities section of this catalog.)

Student Personnel 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 freshman and who direct him to more highly specialized aid when needed. The entire program is conducted under the supervision of the dean of residence.

Freshmen 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.

Each student in the College of Arts and Science is considered from the beginning of his course as an individual and his choice of studies is carefully organized in terms of his specific backgrounds of preparation and his 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 individual student and his individual problems for the same purposes. Similarly, the associate dean of the College of Engineering 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 he should consult. 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 peace of mind and his studies.

If a student is uncertain about his vocational plans or he needs to know more about his 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 own progress and further evaluate and refine his thinking about his future goals. Services offered include personal counseling for those students who may need and desire it.

Later, in his 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 and many other related concerns.

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 the draft and 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 of their time to this area 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 relation-

ships with students. Their contributions are invaluable and appreciated all the more because they are largely voluntary.

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 nearest residence hall counselor, professor, or closest campus friend to learn where he can receive the help he needs.

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 one-half day on Saturdays and Sundays.

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 bed care are sent home or to local hospital when indicated. Any 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, his family, or his Health Insurance Plan.

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

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 his own 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 completion and return to the Director of 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 Department of Physical Education 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 and oral polio 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.

X-ray Services. The X-ray equipment of the Health Service includes a diagnostic unit. Work is limited to chest X-rays and extremity X-rays. No pictures are taken of organs which require contrast media such as dyes, barium, etc.

A small charge is made to cover the cost of reading the films by a local radiologist.

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, ultra-violet and infra-red lamps.

Personnel. Full-time Health Service personnel normally include three physicians, a physiotherapist, a laboratory and X-ray technician, two registered nurses, two night medical attendants, a secretary, 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 which are not performed by the Health Service, 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 this 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. This office 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 are intended to help the student achieve his maximum effectiveness in his course work and studying, his professional development and his 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 studies and choice of major, or very unhappy about his social success and his ability with people, he may undertake personal counseling aimed at helping him understand his direction and motivation. Psychotherapeutic counseling, in particular, encourages the student to explore the sources of his feelings, to consider their influence on his behavior and to discover new ways to manage his 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 the major professional activity of this office, 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 personnel functions. The results of such research are ultimately useful in the counseling of individual students.

Placement Services

The University provides a centralized placement service to alumni, graduate students and seniors. It also serves underclassmen seeking summer employment.

In addition to arranging interviews with prospective employers, the Placement Office has a staff of qualified counselors who are prepared to provide career information and counseling. Lehigh students and alumni are encouraged to avail themselves of this counseling service in planning and establishing suitable career goals.

Alumni are asked to register with the Placement Office if they wish assistance in changing positions or seeking new employment.

Annually several hundred industries, business firms and government agencies send representatives to the campus to interview candidates. In addition to those who visit the campus, there are many employers who seek candidates by direct referral.

A well-developed library of employment literature is maintained for the use of candidates.

The Educational Placement Office in the School of Education handles placement of teachers and other educational personnel.

Reading and Study Clinic

There are many factors which influence the perfor-

mance of college students. An important one is the expertness 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, 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.

Student Activities and Events

Extra-curricular 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 University the philosophy of extra-curricular 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 the participating students.

The University Forum

The question of student representation in University policy-making has been a major one in this decade. 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 library, 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 overall 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 Forum, the strength of the Forum lies in the establishment of a representative legislative body composed of equal numbers of students and faculty, so that everyone can feel 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 requesting it.

National 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, in leadership, in performance in R.O.T.C., etc.

Volunteer Service

Varied opportunities for student expression of social responsibility exist at Lehigh through programs sponsored by the Lehigh University Volunteers (LUV) and the Office of the Coordinator of Volunteer Community Services. About 250 Lehigh students currently participate in volunteer service efforts in the Lehigh Valley area in fifteen different programs. The LUV is governed by a board composed of coordinators of the various projects the Council sponsors.

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 4-H, Big Brother, companionship and group work with children and adults in residential mental health treatment facilities, aids to the elderly through Fellowship in Service to Humanity (FISH), legal aid research, income tax service at neighborhood centers, blood assurance, and numerous individual and short-term efforts.

The Foreign Opportunities Committee 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.

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, electronics and satellite tracking.

The musical groups (bands, instrumental ensembles, and glee club) provide group training for qualified students, present concerts and musical programs, and combine their talents in several annual programs. Lehigh's Marching Band, one of the best in the East, is well known for its precision military drills at football games. The band forms two concert bands for the winter and spring seasons: The Concert and the Varsity Bands. The bands perform a number of major concerts during the year. In recent years the Concert Band has performed at New York's Carnegie Hall and Philadelphia's Town Hall, and the Glee Club has toured Puerto Rico during spring vacation. In addition to giving joint concerts with the Lehigh Band, the Glee Club also sings with the choirs of various women's colleges. A significant part of the campus musical scene is the ensemble and chamber recitals. The musical programs are noteworthy for the performances by non-majors.

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 of Lehigh University publish a semi-weekly newspaper, the *Brown and White*, and a yearbook, *The Epitome*. The students' modern radio stations, WLRN, 640 kc., and WLVR-FM, 91.3 MH_Z, both broadcast throughout the day.

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

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 services are arranged by the Chaplain to 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 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 members of the student body.

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; freshman teams in most of these sports. Sched-

ules are arranged chiefly with eastern colleges which have athletic policies similar to Lehigh's.

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 listed in the preceding section.

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, awards are given for group and individual excellence. The fact that ninety teams participated last year in the basketball leagues alone indicates the extent of the intramural program.

Special Events

Students are encouraged to attend the many musical, theatrical, and special events on the Lehigh calendar. Programs of great variety and depth are arranged by the Committee on Performing Arts, the Cleaver Foundation, the Department of Music, the Student Activities Council, and the music organizations of Lehigh. Recent concert series have included the Newport Folk Festival, the Turnau Opera Players, the Bach Aria Group, the Aeolian Chamber Players, the Cologne Chamber Orchestra, the Vienna Octet, and the New York Pro Musica. In conjunction with choruses of women's colleges the Glee Club has performed choral masterpieces including the Stravinsky-Cocteau opera-oratorio, "Oedipus Rex." The annual Pops Concert, presented by the combined musical organizations 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, Dick Gregory, Wehrner Von Braun, Jane Fonda, Howard Zinn, Charles V. Hamilton, Daniel Mahoney, Joseph Heller, Isaac Asimov, and Tom Hayden. Many of these speakers have appeared under the auspices of the Forum for Visiting Lecturers.

A noteworthy feature of the special events calendar for any year is the annual Jacob Blaustein Lectures in International Relations which presents an outstanding public figure speaking on crucial questions of international relations. Lecturers have included Sir Denis Brogan, General Maxwell D. Taylor, Belgium's Paul Henri Spaak, Israel's Abba Eban, W. Averell Harriman, James Reston, and Harold Wilson. The lecture series was established at Lehigh 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.

Another recent addition to the program is the Globus Series in the Avant-Garde Creative Arts. This series, begun in 1969 through an endowment gift from New York investment banker Morton Globus, features theatrical productions, art and sculpture exhibits, multi-media shows, and experimental films.

The department of fine arts arranges a series of monthly exhibits, including works by contemporary American artists and sculptors, as well as industrial, photographic, and student art shows. The University's permanent collection of art is displayed in several buildings on the campus.

General Information

General College Division

The General College Division, plans for which were approved by the faculty on April 6, 1942, was organized to supplement 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 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 he 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.

Academic Regulations

Eligibility for Degree

In order to be graduated, a candidate for a baccalaureate degree must achieve a minimum cumulative average of 1.70.

To be eligible for a degree from Lehigh University, a student not only must have completed all of the scholastic requirements for the degree, but also he 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 which are protected by properly executed notes approved by the Treasurer.

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 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, B, C, D, and F. A, B, C, and D are passing. 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 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 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 student who withdraws from a course during the first twelve weeks of instruction will receive a grade of "W." A student who withdraws from a course after the first twelve weeks of instruction 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 twelfth week of instruction shall receive 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 must have achieved sophomore standing, have declared a major, and he must be in good academic standing.

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

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

4. A student must have his 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 his students is taking the course

pass-fail. Therefore, he reports a regular letter grade for the pass-fail students. The registrar will then record "P" for reported letter grades of A, B, C, and D and an "F" for a reported letter grade of F.

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

Probation and Drop Regulations

The scholastic requirements for each student are expressed in terms of his cumulative scholastic average (the weighted point average of all grades received 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; B, 3; C, 2; D, 1; F, 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 shall 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) His cumulative scholastic average falls below these levels:

Freshman, 1st Semester	1.30
Freshman, 2nd Semester	1.40
Sophomore, 1st Semester	1.50
Sophomore, 2nd Semester	1.60
Junior, 1st Semester, and thereafter	1.70

(b) He fails more than 7 semester hours in one semester.

The designation "Freshman, 1st 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 exception to this rule.

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

Dropped for Poor Scholarship. A student who makes a 2.20 average or better in his probationary semester but fails to meet the standards set forth in paragraph three above is continued on scholastic probation for another semester. A student who makes less than a 2.20 average in his probationary semester and fails to meet the standards in paragraph three above is dropped for poor scholarship.

Honors

Honors are of four kinds: class honors, graduation honors, departmental honors, and interdepartmental honors. (For departmental and interdepartmental honors, see Comprehensive Honors Program in the Special Academic Opportunities section of this catalog.

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 year.

The names of these students are announced at the Founder's Day exercises and published in the Founder's Day 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 his last four semesters in residence at Lehigh which qualified him 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 official 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.

In computing the averages of candidates for graduation honors, semester grades are weighted according to the number of credit hours in the course concerned on the basis: A equals 4, B equals 3, C equals 2, D equals 1, and F equals 0.

Review—Consultation—Study Period

The Review—Consultation—Study (R.C.S.) 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 of their courses. Faculty members will make themselves available to their students at announced times during the R.C.S. period, for example, at the hours when they meet classes during the formal instruction period. No quiz may be given during this period.

Social Regulations and Procedures

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 academic community are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth.

Out of concern for individuality and respect for the privacy of all persons, the University does not seek to impose a common morality on its members. However, institutional existence 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. For these reasons the University has the obligation to establish certain standards of conduct appropriate and applicable to the University community.

Lehigh University 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 the University as a community.

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.

In general, University regulations are not concerned with conduct on the campus, but all must recognize that whether on campus or off-campus, they are subject to the laws of the Commonwealth of Pennsylvania and the United States. Their responsibilities as citizens require that they conform to the laws of the land, realizing that the University shall not provide a sanctuary for individuals who violate their citizenship obligations. At the same time, the University is concerned with the students' rights as citizens with equal protection under the law, and will endeavor to direct them to legal counsel as may be necessary.

For educational purposes the University reserves the right to review any action taken by civil authori-

ties regarding its members. Although ordinarily the University will not impose further sanctions after law enforcement agencies have disposed of the case, it does have the obligation to introduce counseling and/or disciplinary action if the individual's conduct has interfered with the University's exercise of its educational objectives or responsibilities to its members.

The University as a part of the community has an obligation to its members to report serious crimes to the appropriate civil authorities.

The University relies primarily on general principles and statement of expectation for the guidance of conduct, and it is assumed that those admitted to the academic community of Lehigh are capable of governing themselves accordingly. Specific regulations are kept to a reasonable minimum and are intended to avoid necessary limitations having no educational relevance. Students are advised to consult the Student Handbook for details governing applicable regulations, disciplinary procedures, and due process codes.

Alcoholic Beverages. While in attendance at Lehigh, students are subject to the laws of the Commonwealth of Pennsylvania. Their responsibilities as citizens require that they conform to the laws of the Commonwealth. In this respect, attention is called to the Pennsylvania Liquor and Penal Codes which provides that any person less than 21 years of age who attempts to purchase, purchases, consumes, possesses, or transports any alcoholic beverages within Pennsylvania is subject to fine or imprisonment or both. The selling or furnishing of alcoholic beverages of any kind to persons under 21 years of age by any agency or person is prohibited. It is also illegal to misrepresent one's age to obtain such beverages or to possess or transport liquor not purchased according the Pennsylvania law.

In accordance with these regulations, the University has the following policy with respect to alcoholic beverages:

(1) Alcoholic beverages are prohibited on all University grounds, in all non-residential buildings, in Taylor Stadium and all playing fields.

(2) A student with a guest at the University is responsible for his conduct and for making Pennsylvania law known to him.

Drugs. In recent years there has been considerable publicity regarding the illegal traffic in drugs and increased activity of enforcement agencies involving college students. State and Federal laws prohibit all use and distribution of illegal or dangerous drugs without medical prescription. It is most necessary that students familiarize themselves with these laws, some of which are very severe, and recognize that the University campus is not a sanctuary from the law. A summary of relevant laws is made available to students by the University.

The University is particularly concerned with drug use which leads to behavior harmful to others and to the drug user himself. The University undertakes, through student and staff (e.g., Counseling and Health Services), to provide objective information about drugs and to offer assistance to students with problems associated with drugs, in recognition of the fact that in all cases of drug involvement the responsibility clearly rests with the individual student. When a student's involvement with drugs impairs his effectiveness as a student, his student status may be discontinued until he can again function effectively in the academic community.

No student can expect the University to serve as a cover for an illegal drug market, whether consumers be on campus or off. Where there is serious involvement or a repeated problem in the trafficking of drugs, decisive action will be taken.

Guests. Recent liberalization of visiting regulations for guests is to be understood in terms of the University's essential character and some fundamental educational principles. As a predominantly residential institution, the right of each student to privacy is naturally limited by the rights of his roommate. Thus, the use of a room for social purposes would not be at the expense of another's legitimate use of the room for sleep or study.

Motor Vehicles. Students at Lehigh University are permitted under certain circumstances to have motor vehicles while attending the University provided that the vehicles are properly registered with the Office of the Dean of Students. This privilege will be revoked whenever it appears that a student is guilty of reckless or inconsiderate driving, or that he willfully disobeys University regulations governing the use of or parking of his vehicle. The term "motor vehicle" includes automobiles, motorcycles, motor scooters, etc. New students are not permitted to have or to operate motor vehicles during their freshman year. Exception may be made by the dean of students for commuting freshmen, for freshmen living at home, or for medical

or other exceptional reasons upon petition from the student. Also, financial aid students may not own or operate motor vehicles while at the University unless they accept a $300 decrease in aid or make petition to the Financial Aid Committee.

Dissent. The University faculty has a policy on dissent 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. Primary authority for discipline rests with the faculty and its Committee on Discipline.

The Scene

The map on page 32 of this catalog shows the buildings on the campus, including the fraternity houses and residence halls. The following listing provides a brief description of those buildings most frequented by students and faculty and an introduction to the educational facilities.

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 building houses the offices of the president and his staff, the treasurer and the business offices, the registrar, admission, development, public information, and alumni association offices.

A varied display of paintings, drawings, prints or sculpture by two or more nationally recognized artists is presented in the Alumni Memorial Building Galleries. These exhibitions are changed each month. The Permanent Collection, comprising a group of finely chosen works presented to or acquired by the University are displayed in these galleries and are shown in the offices and library areas about the campus. Several of the finest pieces are displayed on the walls of the University Center and in the Allen Corson DuBois Gallery of Maginnes Hall.

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

Christmas-Saucon Hall has historic interest because Christmas Hall is the first building of Lehigh University. The double building has offices and classrooms primarily used by the department of mathematics, as well as office facilities for the University placement and personnel services.

Fritz Engineering Laboratory is named for the late

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 gave the University funds in 1909 for the erection and complete equipment of an engineering laboratory. In 1955, a seven-story addition to the original structure was opened. It houses a universal hydraulic testing machine, capable of applying a 5,000,000-lb. load to tension or compression members up to 40 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 Mrs. Mary Packer Cummings, daughter of the founder of the University, was built in 1887. Sunday services, special religious programs, music recitals, and the annual Bethlehem Bach Festival are held in the chapel. A coffee house operated by students is located in the basement.

Taylor Gymnasium and Field House were donated by the late Charles L. Taylor, class of 1876. Following World War II the gymnasium was remodeled, re-equipped, and expanded as one of the major projects of the Lehigh Progress Fund. The gymnasium includes a swimming pool, 75 by 42 feet, ranging in depth from 5 to 10 feet; five basketball courts: weight room; fencing room; and class and meeting rooms. Adjacent to the gymnasium and field house is Taylor Stadium, a nine-acre facility providing football and baseball fields, with a seating capacity of 16,000.

The Physics Building is a five-story structure devoted entirely 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 William H. Chandler Chemistry Building is named in recognition of Dr. Chandler's 35 years' service as professor of chemistry, 1871-1906. The east wing, built in 1939, is named the Harry M. Ullmann Chemistry Laboratory in recognition of Dr. Ullmann's service as department head. The three-story fireproof building provides spaces for offices, classrooms, and student laboratories, in addition to laboratory space and equipment for research institutes.

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, a research facility sponsored by several industrial firms which was formed at Lehigh in 1946. The laboratory also provides offices for the University Provost.

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

Linderman Library houses 525,000 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 repository for a wide selection of U.S. government documents. A special 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 facilities for an all-night study room. A special feature is the use of the library by the Center for Information Science for information retrieval experiments. 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 laboratory 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 tempera-

ture 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 four-story structure opened in 1970, houses the office of the dean of the College of Arts and Science, offices and classrooms for the departments of English, history, government, international relations, classics and religion. It also provides offices for the curator and director of exhibitions. From this office, students and faculty can arrange for rental of more than 600 framed reproductions from the collection of lithographs, etchings, dry points and other graphics. Guide service and gallery talks can also be scheduled.

The University Bookstore is located on the ground floor of Maginnes Hall, with its main entrance on the north side of the building. 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 drug 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, psychology, and the Center for Marine and Environmental Studies. The building was renovated in 1956, when a fourth story was added to the original structure.

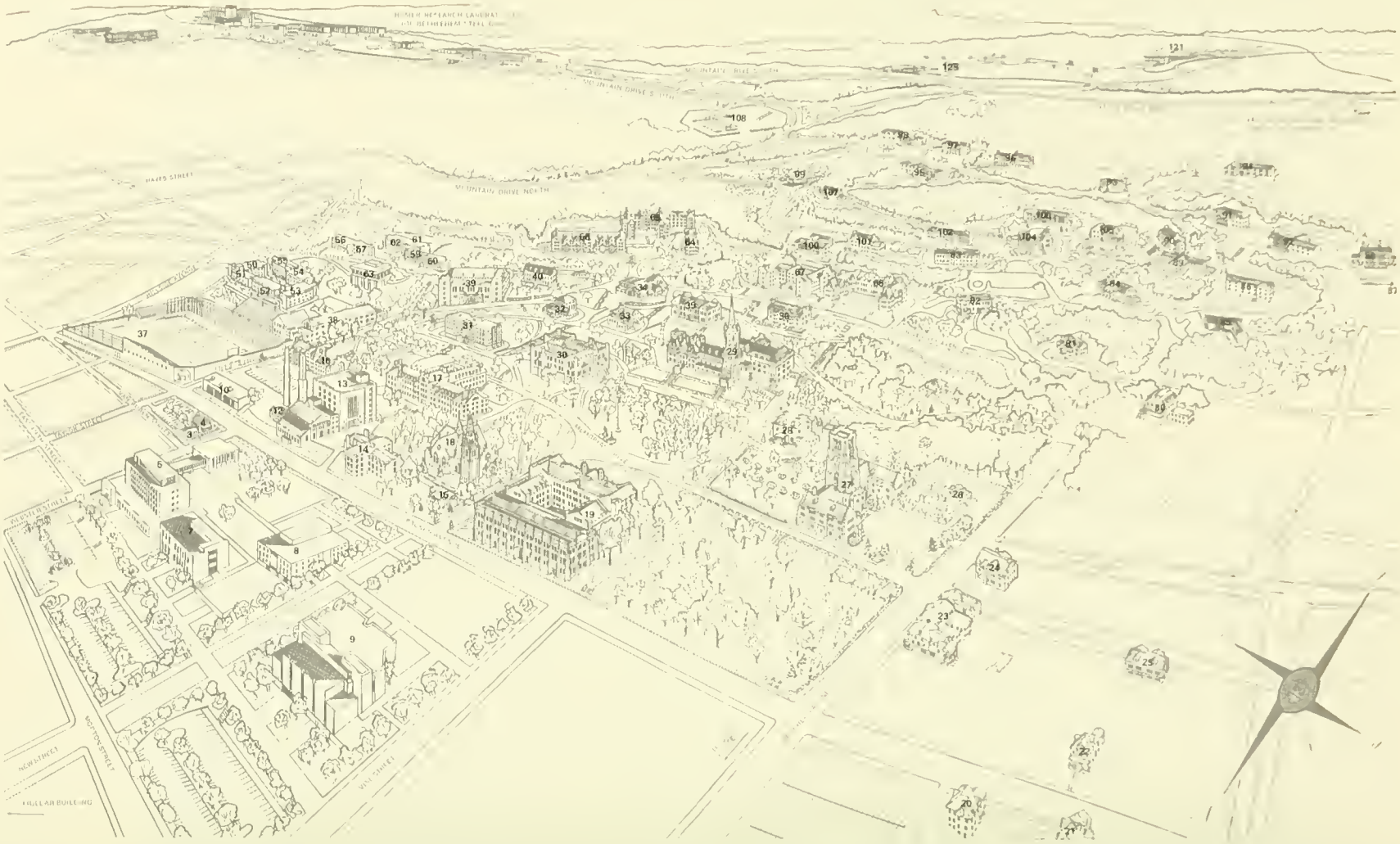
Eugene Gifford Grace Hall, named for the donor, a member of the class of 1899 and president of the Lehigh Board of Trustess from 1924 to 1956, is devoted to sports and recreation. The building is used primarily for basketball and wrestling, and also serves as an assembly room for concerts and lectures. It seats over 3,000. The third floor provides classrooms and offices for the ROTC departments.

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 at one time was the first University gymnasium.

The interior of Packer Hall, the University Center, the original structure given Lehigh by its founder, was razed and completely reconstructed in 1958, and a large addition was built to the rear and west of the original building. The UC, as the building is known on campus, provides student, faculty, and guest dining rooms, lounges, a snack bar, offices for the student newspaper and radio stations, the University Forum, student organizations, meeting and conference rooms, and offices for the Vice President and Dean of Student Affairs and the Dean of Student Life and their staffs. The University Center walls are hung with many excellent pieces from the University's Permanent Art Collection.

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.

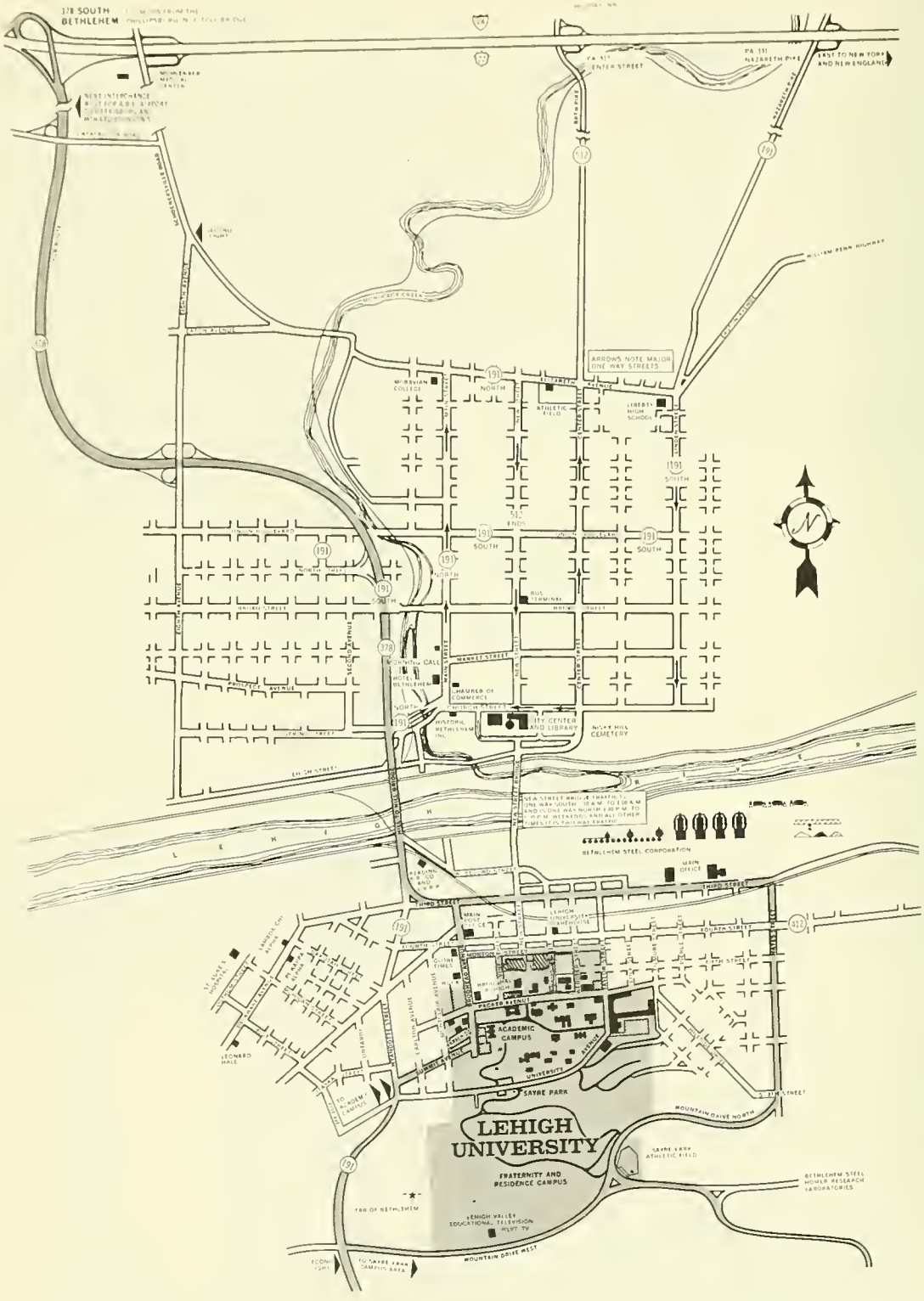
Lamberton Hall houses the department of modern foreign languages and literatures. The department of music also uses the building, with rehearsal rooms for the band and glee club.


MOUNTAIN DRIVE NORTH
HAYS STREET
NOYES STREET
SCOTTON STREET
HOLLAR BUILDING

Academic Buildings and Services

Residence Halls and Fraternity Houses

Research Centers and Institutes and Academic Deans' Offices


ARROWS NOTE MAJOR ONE WAY STREETS
ACADEMIC CAMPUS
SAYRE PARK
LEHIGH UNIVERSITY
FRATERNITY AND RESIDENCE CAMPUS
MOUNTAIN DRIVE NORTH
MOUNTAIN DRIVE WEST
BETHLEHEM STEEL CORPORATION
MAIN OFFICE
THIRD STREET
FOURTH STREET
MARKET STREET
CENTER STREET
MAIN STREET
NEW STREET BRIDGE TRAFFIC
ONE WAY SOUTH 10 A.M. TO 6 P.M.
ONE WAY NORTH 6 P.M. TO 10 A.M.
MUSEUM, INTERNATIONAL AND ALL OTHER
VEHICLES, FOOT AND FREIGHT TRAFFIC
LEHIGH VALLEY EDUCATIONAL TELEVISION WLVT TV
BETHLEHEM STEEL HOMER RESEARCH LABORATORIES
SAYRE PARK ATHLETIC FIELD
LIBERTY HIGH SCHOOL
MORAVIAN COLLEGE
CITY CENTER AND LIBRARY
HISTORIC BETHLEHEM INC.
CHAMBER OF COMMERCE
BUS TERMINAL
MOUNT OLIVET CEMETERY
LEONARD HALL
TO ADAM CAMPUS
TO SAYRE PARK CAMPUS AREA
PA 191 NAZARETH PIKE
PA 512 CENTER STREET
LEHIGH VALLEY MEMORIAL HOSPITAL CENTER
WILLIAM PENN HIGHWAY
LEHIGH RIVER
N

College of Arts and Science

John W. Hunt, *Dean*
G. Mark Ellis, *Assistant 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) a four-year curricula in the fields of biology, geological sciences, psychology, and environmental science 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.

The Bachelor of Arts Degree

The curriculum in Arts and Science emphasizes a liberal education. It asks the student, in collaboration with his 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 object of the distribution requirements is to give the student an elementary knowledge of the fields of contemporary thought and to orient him in 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.

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.

Honors students may, with the approval of the dean, substitute Creative Concepts seminars for distribution courses other than foreign languages.

Mathematics

One course: Math. 21, 31, 41, or Phil. 14 or equivalent.

Foreign Languages

The principal purpose of studying a foreign language in the College of Arts and Science is to develop a means of perceiving and thinking of a culture other than one's own. Accordingly, the student is asked to choose his language of study on the basis of a desire to know more about some non-English speaking part of the world.

Each student is required to achieve working proficiency in the four language skills—speaking, listening, reading and writing. The number of hours varies depending on the language selected and previous study in the language.

A student is not allowed to receive college credit for course work in a language taken at a level lower than his previous study of that language warrants.

With the approval of the Dean of the College, an option is offered those who find it necessary to pursue in college the study of two foreign languages, provided that neither language was studied in secondary school. Such students may offer in satisfaction of the language requirement second-year level proficiency in one foreign language and first-year level proficiency in another.

Qualified students are encouraged, to the extent that their courses of study permit it, to participate in approved Study Abroad programs as these may from time to time be maintained by the University or approved for participation by Lehigh students.

Humanities

Twelve semester hours must be chosen from at least two of the following groups:

1. Literature (Courses in English or American Literature; Greek, Latin, or modern foreign literature in translation; or literature courses at the third-year

level or higher in a foreign language, provided that such courses are not also used to satisfy the foreign language requirement)

2. Fine Arts, Music or Archaeology
3. Philosophy
4. Religion Studies

Natural Sciences and Mathematics

Twelve semester hours, chosen from at least two of the following groups:

1. Astronomy
2. Biology
3. Chemistry
4. Geological Sciences
5. Mathematics
6. Physics
7. Psychology

Social Sciences

Twelve semester hours, chosen from at least two of the following groups:

1. Sociology, Cultural Anthropology, Social Psychology
2. Ancient Civilization, History, Archaeology
3. Government, International Relations, Economics
4. Urban Studies

Major Field of Concentration

During the second semester of the freshman year if possible, and in any event no later than the end of the sophomore year, each student in the curriculum of Arts and Science will select some sequence of studies as his 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 major courses. It is expected that the student will prepare himself largely through his own reading.

Standard Major Sequences

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

When a student selects one of these standard majors, the chairman of the department offering the major or the official director of a non-departmental major becomes a student's major advisor and makes out his 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 official major and is expected to maintain normal progress in fulfilling its requirements.

The 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 will take more courses in his major field of concentration than will his counterpart 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 pages under the appropriate alphabetical listing.

Arts-Engineering

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 he will complete work for his degree in the College of Arts and Science at the end of four years. He will transfer for his fifth year to the appropriate department of engineering, where he will pursue a regular fourth year of science and engineering course work in his chosen field of engineering.

These arrangements make it difficult for an Arts-Engineer to qualify for his B.S. in the College of Engineering before he has met all requirements for his 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 art 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 environmental science 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 degree of Bachelor of Arts.

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

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 or air science 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 described under Academic Regulations.

The Bachelor of Science Degree in Biology, Geological Sciences, Psychology, or Environmental Science 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 R.O.T.C. credit may be counted towards graduation credit;

2. Completion of all general requirements applying to all candidates for baccalaureate degrees described under Academic Regulations.

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-Engineers.

Comprehensive Examination or Senior Thesis

The comprehensive examination in the major field or a senior thesis is required of students in a few major fields of concentration. The student should consult the major sequences to determine which majors require successful completion of a senior comprehensive examination or a senior thesis.

The comprehensive examination is given under the direction of the chairman of the major department. No student is allowed to take a senior comprehensive examination more than twice in any one field. In case of failure on the first attempt, a second trial is not permitted until a period of three months has passed.

Special Opportunities

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 (other than accounting, economics, or finance) 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 his first four years the student takes background courses in business and economics. If he successfully completes these and is admitted to the graduate phase of the program, he may expect to complete remaining requirements for the M.B.A. degree in one additional year.

The background courses to be taken during the undergraduate years will be found listed under the Five-Year Programs under description of courses, together with additional information concerning the M.B.A. program.

Honors and Independent Study

Qualified students in all curricula of the college may choose to work for either departmental or interdepartmental honors. Particularly well-qualified students sometimes work for both. These programs are described under the comprehensive honors program later in this catalog.

Students will find various opportunities for independent study in all curricula and in 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, a junior or a senior of unusual merit who wishes to concentrate in his chosen field may be allowed to substitute not 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 a student 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. The student should see his major advisor or the dean of his college concerning these opportunities.

College of Business and Economics

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

Programs of Study

The College of Business and Economics, which is a member of the American Association 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 of 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 non-profit 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 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 percent of 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 a solid understanding of business and the economy. It is frequently combined

in five-year programs with other bachelor's degrees in arts or engineering, and may lead directly to a fifth year achievement of the M.B.A. degree in the college or in some other institution.

Objectives

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 upper class 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.

Curriculum for B.S. in Business and Economics

120 hours required for degree.

College Core Requirements (52 credits)

English and Mathematics (15 credits)

Engl 1	Composition and Literature (3)
Engl 2, 10, 14, or 16	Composition and Literature (3)
Math 41	BMSS Calculus I (3)
Math 42	BMSS Probability (3)
Math 43	BMSS Linear Algebra (3)

Business and Economics Core (37 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	Marketing (3)
Fin 225	Business Finance (3)
Mgt 201	Development of Management Thought (3)

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

Major Program (15 credits)

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

Optional Courses (30 credits)

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

(1) English, speech, journalism or modern foreign languages 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 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 (23 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 6 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 will register for Economics 1 his freshman year. For the fourth and possibly fifth courses, he will take courses toward the optional requirement each semester of his freshman year. The normal program for freshmen is fifteen hours each semester.

Accounting 51 is normally 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 his major by fall pre-registration in his 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.

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 is generally though not always terminal 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 M.B.A. 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 profession or 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. A comprehensive examination is required of all candidates for the M.B.A. degree.

First Year Program (30 hours)

Quantitative Methods and Systems

Acctg 108	Fundamentals of Accounting (3)
Acctg 111	Computers in Business (3)
Eco 45	Statistical Methods (3)
Mgt 302	Quantitative Models—Conceptual (3)
	or
Mgt 314	Operations Analysis (3)

Functional and Organization Studies

Fin 225	Business Finance (3)
Mkt 211	Marketing (3)
Mgt 321	Organization Behavior (3)
	or
Mgt 201	Development of Management Thought (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 (3)
	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. However, each candidate is urged to take at least 6 to 9 credits of electives in one of the fields in which work is offered in the college. He will be considered to have majored in the field if he takes 9 hours of electives in a field including at least six hours at the four hundred level. Thus, for example, he may major in accounting, finance, labor relations, international trade and finance, management science, marketing, etc.

Of the total of 60 credits, the last 30 credits are taken in residence and must meet the University graduate requirements for any master's degree.

Graduate Work for Research and/or Teaching in Business and Economics

The Ph.D. Degree

The philosophy of the Ph.D. program is to nurture the individual's intellectual growth so that he may independently pursue professional objectives. It is assumed that the individual's level of proficiency, attained at the completion of his degree program, will continue to increase with his professional development.

The student is expected to pursue an intellectual and scholarly interest in four areas, including economic theory. His program of study in these four areas is arranged with the chairman of the Ph.D. committee of the college. This program of study is designed to prepare the student to pass general examinations in his four areas so that he may be admitted to candidacy. Course requirements include competence in quantitative analysis at least through Economics 352, Statistical Methods (3) and Management 314, Operations Analysis (3) and a course in the history of economic thought. Once the student has satisfactorily completed his general examination, a dissertation committee is organized and its chairman guides the candidate in the preparation of his 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 18 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 above plus Economics 352, Advanced Economic Statistics (3), and Management 314, Operations Analysis (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.

College of Engineering

John J. Karakash, *Dean*
Robert Gallagher, *Associate Dean*

The Curricula

The College of Engineering 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 need of industrial life. Present-day 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 science and of 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 freshman choice of a specific curriculum may be changed prior to the sophomore year without loss of time. During the first year, any student who is uncertain as to his curriculum should consult with his faculty advisor. In the second semester of the freshman year, just prior to preregistration for the sophomore year, each student elects a particular 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 without having to make up courses. There are instances, however, where such a transfer will 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 so that they may be able to apply these to the problems they encounter following graduation. 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 an M.S. 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 to also 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 identified with 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 which call for six to twelve credit hours over the "minimum" programs. Actually, the college, through its advisors, will be prepared to help students to use these six to twelve hours of "personal electives" along with other electives as available, toward a personal interest development program. This may take the form of some concentration in an option or specialty within a students' own degree program, or alternately in a topical area not necessarily within a student's own department.

Recommended Freshman Year

The following outline of work for the freshman year is most easily scheduled and satisfies the appropriate requirements for all engineering students. For schedules of the work required of the following three years, please refer to the specific curricula under description of courses.

Freshman Year, First Semester (15 or 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
	Social Science GS Elective (3 or 4)

Freshman Year, Second Semester (15 or 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
	Social Science GS Elective (3 or 4)

*Note: A student is free to substitute for English 2 any one of the following three courses: English 10, 14, or 16. (See page 141.)

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 may choose to elect a three-credit social science course (GS) from the fields of government, history, international relations, or social relations. Alternately, freshmen may elect to complete Economics 1, which is required of all students in the college, and thereby postpone their choice of a social science elective.

General Studies

The General Studies program is designed to enable students to range widely or to delve deeply in the humanities and the social sciences with the purpose of exposing them to 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 a student pursuing the B.S. program in the College of Engineering can, if he so chooses, organize his general study program in a manner which also achieves 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. Interested students initiate action by arranging a conference with the chairman of general studies.

2. Submitting to the chairman of general studies a proposed course program in the area of concentration as formulated jointly by the student and a member of the faculty representing the area of concentration. The names of such faculty representatives will be forwarded to students by the chairman of general studies upon approval of their choice of area of concentration.

In general, the "minor" is earned upon completion of a program of not less than 15 credit hours in the area of concentration. In each and every case the faculty advisor in the area of concentration must recommend the student's work for such recognition. It is desirable that students planning to earn a minor through general studies apply soon after their freshman year but not later than the beginning of their fifth term.

The general studies sequence starts in the freshman year with six hours of English composition and literature, and in the sophomore year four hours of economics. By the end of the senior year, a minimum of 15 additional hours (5 courses) are elected 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 particularly to meet general studies objectives.

The general studies courses 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 & Banking (3)
Eco 206	Microeconomic Analysis (3)
Eco 303	Economic Development (3)
Eco 305	The Economic Development of Latin America (3)
Eco 307	History of Economic Thought (3)
Eco 308	History of Economic Thought (3)
Eco 309	Comparative Economic Systems (3)
Eco 310	Economic Evolution (3)
Eco 311	Economics of Resource Use (3)
Eco 312	Urban Economics (3)
Eco 316	Intermediate Macroeconomic Theory (3)
Eco 335	Manpower 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 for elementary study in any language in which he has entering credit.)

Government: 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 II (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 21 (SR 21)	Social Psychology (3)
Psych 107	Developmental Psychology (3)
Psych 121	Encountering Self and Others (3)
Psych 251	Psychological Perspectives in Technological Society (3)
Psych 331	Humanistic Psychology (3)
Psych 361	Personality (4)

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 the University requirements described under the academic regulations section of this catalog. 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 credit hours are in addition to the credit hours specified by the curriculum. Students are encouraged to confer with their curriculum advisor on all matters related to their program.

Honors Programs

Outstanding students in the college may participate in the Comprehensive Honors Program. 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 see the section on the Comprehensive Honors Program.

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 engineering curriculum of his choice. In the fifth year the student is enrolled in the College of Engineering, carrying on a program leading to the degree of B.S. 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.

Special Academic Opportunities

Lehigh's 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, p. 69). The graduate student may also do his thesis or dissertation research in one of the eight interdisciplinary centers, which are described in detail on pages 71 to 81.

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. In the College of Engineering, a student may develop a minor in a field of his interest, not necessarily even in his college. In the College of Arts and Science, special interdisciplinary majors may be individually developed to suit a student's needs (see page 36). Current examples of such programs include such combinations as fine arts and history, information science and electrical engineering, business and psychology, mathematics and social relations, and journalism and urban studies.

Alert to the increasing desire of students for courses related to contemporary and political problems, the faculty has developed interdisciplinary programs in such areas as urban studies, oceanography, environmental sciences and resource management, fundamental science, American studies, and Afro-American studies.

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 plan ning 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 colleges of the Lehigh Valley.

Further information on the other programs listed above may be found by consulting the index.

Opportunities

High Immediate Relevance Courses

In addition to the sensitive topics outlined above, 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 proved 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 HIR courses includes: Media and Values; Fiction and the Technological Vision; Physics for Poets; Art, Technology and Environmental Sculpture; Economics and Society; Seminar in Oriental Religions; Television Workshop; and The Black in American Literature.

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, 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 flexi-

bility extends to late changes of major or even college without loss of credits.

The graduate student may find his interests shifting to a new field as he progresses in his educational program or he may wish to strengthen his 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 the student who wishes to change to a new but related field of study after either his baccalaureate or his master's degree.

The student should consult with the director of his previous program and with the director of the new field in which he is interested to establish the course program that will remedy any deficiencies in background and will be of maximum value to him. 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 this 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. An engineering student, for example, who decides at any stage of his study that he wishes 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 he decided 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 a salaried intern in the public schools. After the completion of one year of full-time teaching, the student 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 the student is advised to consult with his advisor in planning such a program.

Pre-Law and Pre-Medical Programs

Although no formal programs exist, Lehigh students have been very successful in attaining entrance to medical, dental and law schools. Pre-med and pre-law programs can be worked out for students in each of the three undergraduate colleges. Coordinated six-year undergraduate programs are now being developed with several medical colleges in Philadelphia. Interested students should consult with their curriculum advisor or the pre-med or pre-law advisor.

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. A research initiate is attached to a specific research project in progress on the campus, serving as an assistant to an advanced graduate student or to a staff member. He assists in experiments, sits in on project conferences, and if occasion permits, undertakes small side investigations appropriate to his competence.

The research initiate may receive degree credit by registering for unrostered work for up to 6 hours per semester. In a few cases, a nominal stipend may be paid for his work, and summer employment is also occasionally available. The student should explore the possibility of becoming a research initiate with his 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 admis-

sion, 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 students, both graduate and undergraduate, in summer school for both remedial and accelerated work, special programs are available for intense in-depth experiences as well as for field work. Examples include the Robert A. Taft Institute of Government and the Field Work in Archaeology program (History 403) run by the department of history and Moravian College. Summer 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 Session.

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 his college career, for a maximum total of six hours of credit. He 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 his department must decide whether the credit he receives for the course will count toward fulfilling his course requirements for a graduate degree. The apprentice will be graded by his 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).

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 University 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 available at a German university with Lehigh credit. The program is open to students with junior standing or above.

The Modern Foreign Languages Department also offers summer language and literature programs in Paris, France, Salzburg, Austria, and Santander, Spain. These programs provide up to six hours of academic credit, and are open to undergraduate and graduate students in good standing at an accredited school of higher learning, and to elementary and secondary school teachers in service.

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 American 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.

Freshman Seminars

Interdisciplinary problem-centered Freshman Seminars (FS) are offered each semester to freshmen enrolled in any curriculum. The seminars deal with primary problems of contemporary culture and are intended to challenge the educational idealism of freshmen. A three credit hour seminar will fulfill general studies requirements in the College of Engineering or distribution requirements in the College of Arts and Science.

Most freshmen courses are introductions to disciplines, that is, courses in which the student learns procedures that will enable him to take more specialized courses. Problem-centered Freshman Seminars are based on the premise that these typical courses should be complemented by studies that relate contemporary cultural problems to the many disciplines in the humanities and in the sciences.

Enrollment in the seminars is limited. Freshman interested in enrolling are invited to complete the appropriate forms distributed with other pre-registration materials and to consult with their faculty advisor.

Typical Freshman Seminars offered in recent semesters include Energy and Society, Change and Crisis in American Colleges, Man and His Man-Made World, Science and Moral Values, The Revolt of the Inarticulate, and Environmental Crises. Freshman Seminars are also offered on a regular basis by some departments as a part of their normal course offerings, for example, History 51 and 52.

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 their individual programs with their major advisors or with the dean of their college.

Cooperative College Program

Lehigh is a member of the incorporated LVAIC (Lehigh Valley Association of Independent Colleges). 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 takes and the grade he makes in it are recorded on the transcript of his 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 his 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 the college in which they are registered.

Any undergraduate may accelerate his program by passing by special examination any course he feels he already has 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 his junior year, an honor student may choose to work for Interdepartmental Honors, or Departmental Honors. Particularly well-qualified students sometimes work for both. An honor student enrolled in one or both of these programs is designated a "University Scholar."

Students with cumulative averages of less than 3.0 may under some circumstances by permitted to work for Departmental Honors.

Departmental Honors

These programs give the University Scholar the opportunity to study in his 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 his 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 4-credit courses, R.O.T.C. and the like, raise it to 17 hours maximum.

c) Honors thesis or project.

A candidate for Departmental Honors must announce to his major advisor during his junior year, or no later than the beginning of his senior year, his 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 his major. The names of those students who attain Departmental Honors will be announced at the graduation exercises.

Interdepartmental Honors

The Interdepartmental Honors Program offers qualified undergraduates the opportunity to devote part of their junior and senior years to independent study through a series of limited enrollment seminars known as Creative Concepts Seminars, and the preparation of a thesis or other project.

The seminars are each based on one of the four large areas of human knowledge: humanities; life sciences; physical sciences; and social sciences. Together with the final thesis or project, they provide a foretaste of the kind of work and of the standards the students will encounter in graduate and professional schools.

University Scholars in this program are graduated with Interdepartmental Honors if, in addition to meeting all requirements for graduation, they have:

(a) Completed three Creative Concepts Seminars with an average grade of at least 3.33, or four seminars with an average grade 3.25.

(b) Completed an Honors Thesis or Project with a grade of "A."

No student who enrolls in the Interdepartmental Honors Program is obligated to complete it; he may, if he wishes, register for only such seminars as appeal to him.

Admission. Each sophomore eligible for admission to the Interdepartmental Honors Programs will be notified of his eligibility before the pre-registration period in his fourth semester. A student is eligible to apply for admission if he has a cumulative three-semester average of at least 3.0.

Each applicant must submit to the chairman of Honors Program an application approved by the chairman of the department in which he is majoring. (Forms are obtained from the chairman of Honors Program.)

The Program. A student admitted to the Interdepartmental Honors Program must:

(a) Continue to pursue a major program since an Honors Program does not constitute a major.

(b) Schedule at least three Creative Concepts Seminars during his junior and senior years. It is possible to schedule only one seminar per semester. The semi-

nars offered carry the following course numbers and broad titles:

Creative Concepts 101: The Humanities (3)
Creative Concepts 102: The Life Sciences (3)
Creative Concepts 103: The Physical Sciences (3)
Creative Concepts 104: The Social Sciences (3).

Under these headings a variety of courses is offered. Instructors are selected from the University faculty, and each is given liberty to pursue any topic and course of inquiry he wishes, guided only by the idea that he will deal in some way with concepts he considers significant in man's attempt to understand himself and his world. Ideally the student should sample at least three of the broad areas, but this is not always possible.

(c) Produce an Honors Thesis or other approved project by scheduling Creative Concepts 190: Honors Thesis (3 to 6 credits) during one or both semesters of his senior year (or during the preceding summer). If unusual circumstances prevent such scheduling, the student can develop other procedures in consultation with the chairman of Honors Programs. The thesis or project must be supervised by a member of the faculty who has agreed to work with the student and who has been approved to do so. The student should submit a proposal signed by the advisor and by the chairman of the student's major department to the chairman of Honors Programs no later than the beginning of his eighth semester.

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, 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 alumni.

All candidates for admission are automatically eligible to compete for one of these prizes and will be so considered. A preliminary selection of finalists will be made in January when prize applications will be distributed and interviews conducted. Winners will be 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.

The Graduate School

Robert Daniel Stout, *Dean*

Areas of Graduate 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 nineties this degree was withdrawn and doctoral work not again offered until 1936, when it was once more authorized by the trustees. In the same year the Graduate School was organized, with a graduate faculty which had full power to enact the necessary legislation governing the work of the school. In 1960 a program of studies leading to the degree of Doctor of Education was first offered. A Doctor of Arts program was begun in 1971.

The rules and regulations of the faculty are developed by a Graduate Committee composed of the President or his representative, the Dean of the Graduate School, and twelve elected members of the faculty.

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, international relations, management science, mathematics, materials, mechanical engineering, metallurgy and materials science, modern foreign languages and literatures, physics, 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, physics, 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 wishes to undertake his graduate work. In addition to the application the candidate should also request that each institution of higher learning which he has attended send directly to the Office of Admission a transcript of his 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 is interested. If it is convenient for him to visit the University prior to completing his admission or prior to registration, a consultation with the chairman of the department (or his representative) will assist the department in working out a program for the student and will aid the student by giving him 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, New Jersey.) 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 for this purpose.

Admission to graduate standing permits the student to take any course for which he 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 major department in order to be readmitted to graduate standing. If the student has not established a major, he 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. He must spend at least 20 hours per week on research and/or course work toward the degree, and he may not receive income from any employment requiring services totaling more than 20 hours per week.

A student is recognized as a candidate for the doctoral degree if (a) he has completed at least one year as a resident graduate student (as defined above) or holds a master's degree or its equivalent, (b) he has maintained a minimum average of 3.0 in his graduate courses, and (c) he has formally notified the dean of the Graduate School through his department his intention to study for the doctoral degree.

This recognition of the student's status as a doctoral candidate is not necessarily an assurance that the student will be able to meet the requirements of the degree.

Special Student

A student who does not wish to 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. He must hold a baccalaureate degree or have equivalent experience. He may register for courses up to and including the 300-level at the standard graduate tuition rate. Admission depends on approval by both the relevant major department and the Graduate School office. Status as a special student does not prohibit a later application for admission as a graduate student.

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 in the office of the Registrar and arranging in advance for an interview with his 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 10-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 $1425 per semester or $119 per semester hour for 1973-74. A listener's fee of $119 for 1973-74 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.

In addition to the usual tuition an intern student is required to pay a $400 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 $660 per semester or $55 per semester hour in 1973-74.

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 $1,000 each semester and summer period. Similarly, part-time doctoral candidates must register for a minimum of 3 credit hours of courses or dissertation until the fees are met. Thereafter doctoral candidacy must be maintained by a registration fee of $100 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 10 hours per semester in the case of TA's and RA's) 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 $119 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 department is $8.

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 9 credit hours or more are entitled to an identification card without charge.

Transcripts

Each student is entitled to one copy of his 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 his department chairman and with the approval of the dean, finds it necessary to reduce his 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 total tuition less $5 for each credit hour for which

he is registered and less a deduction for each day of regular instruction of 1 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 his involuntary induction into the armed forces, fees will be refunded in proportion to the fraction of the semester remaining at the time of the student's death or induction.

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

Degrees

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 major department and of 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 approved program of studies for the degree, provided that the total number of hours in which he is registered and in which he 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 in May 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 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 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 must include:

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 remaining 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" 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 3 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 $15.00 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 work of his program. 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 for the degrees 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 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 special qualifications for work in his chosen field. Each applicant is notified by the Dean of the Graduate School, in writing, of the action of the committee upon his application.

The student and his 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 intends to specialize, certifying that he has a satisfactory command of English.

A special committee is formed to guide the student in his doctoral program. The student should consult with his advisor on the naming of the committee and the preparation of the application as early as possible after he has passed his 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 his dissertation, of overseeing the progress of the student in his 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 special committee, and the chairman of his 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 $8.

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 his proficiency in his 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 may be permitted by the Graduate Committee to present himself for 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; 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 January.

In order that the student receive proper credit for tuition payments toward the miminum 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 his dissertation, he 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. He will arrange a suitable date for the defense of his 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, 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, (c) a residence requirement which 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 section on the School of Education in this catalog.

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 Chemistry Building, with the Chandler and Ullmann Laboratories; and Coxe Laboratory, for metallurgy and the electronic microscopy laboratory.

The University's Linderman Library houses more than 400,000 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 through the nation-wide Interlibrary Loan system.

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 co-operation. 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 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 tend to regard departmental organization more as an administrative convenience than 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 University campus.

It is anticipated that a University-owned and operated apartment complex for married and graduate students will open in fall, 1973. This facility, located in Saucon Valley, will provide 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 Office of the Dean of Residence, Lehigh University.

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

Parking Regulations

Graduate students are expected to comply with campus parking regulations. They should register their automobiles, and secure instructions from the Office of the Dean of Students. 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 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 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, international relations, 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.

In addition to the summer session offerings at Lehigh, students are encouraged to study programs offered at other Lehigh Valley colleges.

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 his tuition and provides an additional stipend to help meet his 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 directly to the stu-

dent.

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 $2400 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 limited number of teaching assistantships are available in applied mechanics, biology, business administration, chemistry, English, education, geology, government, history, international relations, mathematics, physics, political science, 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 $2650 ($2850 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 10 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 his departmental 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 on-going project. The experience enlivens their course work and often determines one's thesis topic. Usually a research assistant's thesis work parallels his 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 which vary from $150 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 $1000 per semester 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 is eligible. Application must be completed on or before February 1. Each application must be supplemented by an official transcript of the candidate's college work, a statement concerning his practical experience, and any other evidence of his qualifications which he 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.

Student Loan Funds

The University administers a sizeable loan fund program under which financial assistance, long-term and short-term, is available to graduate students. A student may borrow when he has no other support from the University, or to add to his income from a fellowship or assistantship. To be considered, a student must provide complete details of his 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 $2500 each year for graduate study to a combined graduate/undergraduate total of $10,000. 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. No payment is required and no interest is charged for any period up to three years during which the student serves in the Armed Forces, Peace Corps or VISTA. The program also provides for partial or total loan cancellation for students who enter the field of special education, and partial cancellation for military service.

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, research specialists, specialists in the foundations of education, specialists in the education of mentally and emotionally disturbed children, 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.

Two hundred nineteen doctoral students, 791 students engaged in M.A. and M.Ed. programs, and 206 post-master's degree students were enrolled in the School of Education in the past academic year.

Whereas graduate study in education was once undertaken only by those preparing for leadership in the schools, it is now a part of the training required

of every qualified teacher. In the face of this mounting trend, Lehigh joined the Lehigh Regional Consortium, strengthened its graduate program, and discontinued professional preparation of undergraduate students.

Accordingly, a fifth-year program is offered to 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 one or 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, they 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, school psychologists, special education, vocational 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 specialists 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 proposal accepted by the Graduate School, he becomes eligible to take the general examination.

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, counselor, elementary school counselor, secondary school counselor.

Division of Elementary Education

Alfred J. Castaldi, *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, vocational education, social restoration.

Division of Educational Measurements and Research

Paul VanR. Miller, *Director*

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:

1. In electrical engineering, research is underway 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 program the following core subjects:

1. Mathematical methods in computer science
2. Non-numerical programming
3. Switching theory
4. Data structures.

Elective courses may be chosen from one or more of the areas listed below:

1. Software and automata theory
2. Hardware and logic design
3. Numerical analysis
4. Linguistics

5. Computability
6. 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 in the charge of an interdisciplinary faculty committee chaired 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 will be 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:

1. Simulation (I.E. 418)
2. Organizational Behavior and Structure (Mgt. 321, I.E. 334, or Mgt. 412)
3. Management Science Project (Mgt. [I.E.] 430)
4. Nine hours of Quantitative Methods
5. 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

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 session). 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 will be 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, 450
ChE 462
(Physics 428 and 429 may be substituted for Math. 320, 322)

Options

1. Engineering Sciences

Required:
Mech 450
Phys 471

Electives:
Math 405
Mech 409, 421, 424, 458, 459
CE 459
EE 350, 409, 457
Phys 369, 442
Geol 301
Biol 402

2. Econometrics

Required:
Eco 206 or 435, 316 or 436, 351

Electives:
Math 309, 334
Eco 453, 455, 456
IE 416, 418, 425, 426, 427, 429, 311

3. Applied Analysis

Required:
Math 309, 350
Mech 450, 451

Electives:
To be chosen from lists under Options 1 and 2.

Research Centers and Organizations

Currently, nine interdisciplinary research centers and five 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.

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 (see page 70), 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 director, Professor Ronald S. Rivlin.

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 4096 words (12 bits each) of memory, approximately 1 billion characters of disk storage, 4 magnetic tape units, 2-1200 line-per-minute printers, a 1200 card-per-minute card reader, 2 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). A Users Area is provided containing teletypes, key-punch machines, and reference materials.

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 on-going cooperative activity.

The center is 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 is expected to benefit immensely this group of users.

The University has established a multi-disciplinary graduate program leading to the M.S. in Computer Science degree. This program is described in detail on page 69 of this catalog.

For further information, write to the director, Professor John E. Walker.

Center for Health Sciences

Background and Purpose

The Center for Health Sciences was organized during the latter part of 1972. It is concerned with interdisciplinary research and graduate and post-doctoral 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 Visual Science, and (4) the Division of Bioengineering. Facilities are provided by these divisions for its members, post-doctoral 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. The Institute for Pathobiology, a branch of the Center for Health Sciences, is an interdisciplinary unit involved with research and graduate and post-doctoral education. Fields currently represented in on-going research projects include virology, microbiology, protozoan and metazoan parasitology, invertebrate pathobiology, immunology, biological control, biochemistry, pollution research, 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. Studies on diseases of marine and estuarine fishes and shellfishes are being conducted in conjunction with the University's South Jersey Wetlands Institute.

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; study of viral diseases and virus-induced tumors in fish; study of the effects of pollution (thermal, chemical, and biological) on marine and freshwater organisms; studies on the intermediary metabolism and other phases of the biochemistry of helminth parasites.

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 on-going research include enzyme biochemistry, intermediary metabolism, medicinal chemistry, biosynthesis of organic molecules, the physical basis of surface adhesion in biological systems, clinical chemistry, and effects of radiation on nucleic acids. 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 mag-

netic resonance instrumentation, mass spectrometers, fermenters, gas and liquid chromatographic facilities, and other allied bioorganic apparatuses.

Division of Visual Science. This research and graduate training unit is also a part of the Center for Health Sciences. The major emphasis within this division is concerned with the phenomenon of vision as approached from the standpoint of the psychobiologist, neurophysiologist, biochemist, and engineer. Most of the division's facilities are currently in Williams Hall as is the administrative office.

The division's laboratories are well-equipped and among the major facilities are a neurophysiological laboratory for single nerve cell recording, human and animal psychophysics laboratories, and the Color Science Laboratory.

Lehigh scientists affiliated with the Division of Visual Science have an on-going liaison program with the Will's Eye Hospital and Research Institute in Philadelphia and some of the projects, especially those pertaining to human vision, are conducted at that facility.

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, on-going 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.

The division's laboratories are housed primarily in Packard Laboratory and the administrative office is in the same building. In addition, several individuals associated with this division are engaged in joint research projects with personnel of the Hahnemann Medical School in Philadelphia and some of the work is being conducted at that facility.

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, psychology, civil engineering, mechanical engineering and mechanics, as well as other departments of the University.

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.

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 for Information Science supports on-going research projects in the theory, design, development, implementation, management, and operation of computer-based information systems. The focus of this activity is the LEADERMART system, which was developed at Lehigh with the aid of a grant from the National Science Foundation to provide a fully automated information retrieval system on-line to Lehigh's time-shared CDC 6400 computer.

Research activity based on LEADERMART includes the development of a prototype health knowledge transfer system, the study of logic flows in medical diagnosis, the application of computer technology to health care, and the design of a question-answering system. The LEADERMART system has been designated as a node in the emerging National Science Computer Network, and serves as a model for projected information dissemination resource-sharing arrangements.

Facilities for LEADERMART research, development, and operation include access to the CDC 6400 in both time-sharing and batch modes, remote card readers, printers, CRT terminals in the Center for Information Science, and teletypes.

There is substantial additional research in the center with emphasis on psycholinguistics, mathematical linguistics, and biomedical 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. Biomedical information system research deals with new techniques of full-text searching, and means for interfacing the LEADERMART system with the teaching and practice of clinical diagnosis.

Educational Opportunities

The Center for Information Science 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.

Center for Marine and Environmental Studies

Background and Purpose

Effective utilization of the resources of the oceans requires the cooperation of many scientific and engineering disciplines. Practical solutions for the many urgent environmental problems will most likely be achieved through a similar combination of scientific and engineering talent. The purpose of the Center for Marine and Environmental Studies (CMES) is to foster a multi-disciplinary approach to research on these broad problem areas. Originally established in 1962 as the Marine Science Center, the scope was expanded to include environmental studies and ocean engineering in 1968 under the new name. 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 these disciplines to problems of 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. The Center for Marine and Environmental Studies 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 done at the off-campus seashore facility of the center, the South Jersey Wetlands Institute (see separate listing in this section under institutes). Lehigh University is a member of the Institute for Development of Riverine and Estuarine Systems (IDRES), a regional multi-institutional consortium organized to conduct research on broad interrelated environmental problems of effective utilizations of riverine-estuarine resources, using the Delaware River Basin and Delaware Bay as a model system. Water quality and pollution studies are carried out on the Lehigh and Delaware rivers and their smaller tributaries. Waste water treatment research is performed in cooperation with local industries and municipal

sewage plants. Through cooperation with other institutions having oceanographic facilities and ships, staff and students affiliated with the center have a variety of opportunities for experience and work at sea.

Current research activities include:

Marine Science. Biochemistry of proteolytic marine bacteria; fate of fatty acids in salt marshes; biological effects of thermal pollution; immunological methods for fish egg identification; winter flounder population studies; ocean dumping pollution studies in New York Bight; sublethal effects of pollutants on key organisms; coastal salt marsh ecosystems; 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.

Ocean Engineering (Marine Geotechnical Laboratory). Development of geotechnical instrumentation for submersibles; establishment of geotechnical test areas in San Diego Trough and Gulf of Maine; in-place measurement of geotechnical properties of sea floor soils in Gulf of Mexico; shear strength and consolidation testing of soft cohesive sea floor soils.

Environmental Studies. Stream recovery after pollution; advanced waste water treatment methods; research needs in regional planning (IDRES); biological regeneration of activated carbon; fluidized bed enzyme treatment of acid whey waste; chemical treatment of fly ash.

Educational Opportunities

Graduate students participating in the center's programs usually receive M.S. or Ph.D. degrees in the traditional discipline of their choice, 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 the departmental and graduate school degree requirements will be arrived at by consultation with the chairman of the student's major department, and will usually include courses in other departments. Courses in marine science, i.e., biological oceanography, chemical oceanography, marine geology, ocean physics, etc., are offered in those and other 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. For course descriptions, see the catalog listings under the various academic departments.

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.

Center for Surface and Coatings Research

Background and Purpose

The Center for Surface and Coatings Research is an interdisciplinary endeavor in which faculty and students with a broad range of scientific interests interact on research relevant to surface and coating phenomena. It combines the expertise and talents of chemists, chemical engineers, metallurgists, physicists, and mechanical engineers in a unified program of research and education, for the most part at the graduate level.

The importance of the center's research, its broad scope, and the need for an integrated approach are readily evident from several considerations: almost every aspect of life involves a surface; surfaces are rarely bare but are usually covered with coatings; the diverse nature of surfaces and coatings requires that many facets of interfaces, colloids, and related sciences be understood.

The center's position of strength in these areas began with the initiation of research in surface chemistry at Lehigh in the early 1940's. The program broadened into the field of chemical coatings in 1946 when the National Printing Ink Research Institute undertook support of research at the University. The two interrelated research programs initially functioned within the physical chemistry curriculum; however, because of the continual growth of the research plus the increasing tendency to interact with other departments, formal center status was conferred in 1966.

The purpose of the center is to encompass all pertinent disciplines in its efforts to develop and promulgate an understanding of surface and coating phenomena. Interaction among faculty and students

is greatly facilitated by the fact that the center is housed in a new building, the 36,000-square-foot Francis MacDonald Sinclair Memorial Laboratory, especially tailored to its needs.

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 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. The Sinclair Laboratory houses equipment for experimental studies employing electron spin resonance, ferromagnetic resonance, flash desorption, Mössbauer spectroscopy, Auger 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: rate of drying of latex films; electrophoresis of latex particles; application of latexes in medicine; emulsion polymerization in continuous stirred tank reactors; rheology and nip behavior in non-Newtonian fluids; adhesion and flow of fluids on porous substrates; water purification by flocculation; characterization of surfaces by adsorption; microelectrophoresis; computerized color matching; estimation of color differences; color constancy and metamerism; light scattering by microvoids; ice formation on low energy nucleants; wetting in multiphase systems; theoretical studies of aluminosilicate complexes; catalytic properties of fresh surfaces; optical spectroscopy of surfaces; Mössbauer spectroscopy of surfaces; Auger spectroscopy of fracture surfaces; environmentally affected crack growth in metals; relation between surface properties and fracture; hydrogen embrittlement of high strength alloys; electrodeposition of intermetallic compounds; pulse electroplating; resistance-capacitance studies of polymeric coatings.

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.

Irrespective of source of financial support, 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. 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 to up-date industrial personnel. The conference center in the Sinclair Laboratory is ideally suited for the special seminars and short courses held periodically. Recent topics include surface analysis, printing ink technology, emulsion polymerization, computer formulation of colorants, and Mössbauer spectroscopy. The center has also hosted national meetings such as Colloid Symposium in 1970, the Carbon Conference in 1971, and a conference on Ecology in the Graphic Arts in 1972. In addition, the center provides opportunities for resident post-doctoral studies and for visiting scientists.

For further information write to the director, Professor Henry Leidheiser.

Center for Social Research

Background and Purpose

The Center for Social Research encourages research in the social sciences particularly where current policies necessitate cutting across traditional disciplinary lines for the solution of social problems. Established in 1965, the center sponsors innovative research programs in economic and business forecasting,

urban studies, behavioral research and manpower studies. These programs involve active groups of graduate students and selected undergraduates who have found the center to represent a campus nucleus of enthusiastic intellectual activity in these areas. Interactions are encouraged with governmental, business, labor and other groups in the community to provide communication, contacts, and common efforts toward solutions of social science problems. Thus the center serves to coordinate and facilitate research, liaison, and problem-solving efforts by faculty and graduate students in the social sciences.

Research Activities

Research activity in the center has ranged widely over various topics in social science. Earlier business and economics research included the development of residential housing forecasting models and college graduate manpower studies of mobility, turnover and career attitudes. Current economic research stresses policy issues in population, migration, and public finance as well as newer aspects of the role of business in a changing environment with respect to growth.

Behavioral research includes on-going work on social agency information systems and key social psychological aspects of attitude and behavioral patterns in modern life. Perceptions of crowding represent a social science dimension of the place of tall buildings in our civilization as do certain aspects of public decision-making in the context of planning for growth. Governmental and economic as well as behavioral contributions are being explored through the center in this connection.

One of the themes currently representing a challenge to social scientists emerges from the impact of governmental fragmentation on delivery systems in the public sector. In addition to cost and efficiency questions, techniques and machinery for conflict resolution and decision-making on these issues represent areas of interest to the cooperating scholars from the several social science departments at the University.

The Urban Studies program stresses research on the inter-relatedness of social, political, economic, physical and historical forces which affect urban life and form.

Educational Opportunities

Research seminars and course offerings in the social sciences are listed in the catalog under the respective social science departments of the University in each college. Thus economics courses and degree requirements are listed under the College of Business and Economics. The departments of government and social relations in the College of Arts and Science have numerous courses basic to research work in behavioral science and/or public policy problems and political processes. The psychology department, the School of Education, the industrial engineering department and the College of Engineering as well as certain courses in the management and accounting departments of the College of Business and Economics also involve course work with active faculty and student interests in the Center for Social Research.

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 achieve an urban concentration through the combined offerings of the social science departments though all take U.S. 416 Urban Seminar. (See urban studies division under government department for recommended combinations of individual departmental course offerings and graduate advisors.)

For further information, write to the acting coordinator, Professor L. Reed Tripp.

Fritz 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, structural model analysis, soil mechanics, and sanitary engineering.

The Fritz Engineering 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, structural model analysis, soil mechanics, and sanitary engineering agencies.

Graduate studies combined with research investigations commenced at Fritz Engineering 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 Lehigh University 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. Throughout their work in research programs, men 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 overall 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); 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 publications 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.

Materials Research Center

Background and Purpose

The Materials Research Center was formally established in February 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; guides the search for new materials by encouraging funda-

mental research and new approaches to materials problems; and assists in developing educational opportunities in materials, in particular, interdisciplinary graduate programs devoted to training for research in materials.

The Materials Research Center also conducts the Materials Liaison Program with industry and government. Founded in 1963, this program encourages the mutual intellectual stimulation of scientists and engineers dedicated to a common problem. The program serves as a means for the exchange of knowledge of materials problems between scientists and engineers associated with the center and their industrial and governmental counterparts by semi-annual day seminars, special lectures, consultation on materials problems and research, distribution of all M.S. and Ph.D. theses 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 the departments of geological sciences and industrial engineering are currently involved in cooperative programs. Communication with these associated departments 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. 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, mechanical behavior laboratory, polymer laboratory, and physical ceramics laboratory, and three service laboratories, the electron microscopy laboratory, the physical measurements laboratory, and the materials clean room.

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 semi-conductor structures and their evaluation and application to integrated circuits; structure and properties of sputtered and evaporated thin films; high temperature oxidation of metals.

Mechanical Behavior. Electron fractography (scanning and replica); effect of stress state and load history on fatigue crack propagation; mechanical behavior of eutectic composite materials; fatigue of polymeric materials and adhesive joints; fracture of bridge steels; low-cycle fatigue.

Physical Ceramics. Press forging (compressive deformation); strengthening mechanisms; correlation between surface condition and strength; thermal stress fracture; strength and elastic deformation; brittle composites; synthesis of mechanisms of wear of ceramic alloy cutting-tools; static and cyclic fatigue of ceramic solids; fracture toughness and crack propagation behavior of refractories.

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; application of electron microprobe to salt diffusion in 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.

Course offerings in materials are summarized under five-year programs as well as under department headings. In addition, a special program leading to an M.S. in

materials is found under five-year programs.

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.

Institutes

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 lasting 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 Lawrence Henry Gipson Institute for Eighteenth-Century Studies 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 Lawrence Henry Gipson Institute for Eighteenth-Century Studies, and other funds raised by the council, will provide for:

Faculty research grants to defray travel costs, 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 will 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 will stress the inter-relationship of history, politics, literature, fine arts, philosophy, psychology and the sciences.

Annual symposia to honor the late Professor Gipson, involving a distinguished scholar in eighteenth-century studies to give lectures and also to discuss opportunities for further scholarly exploration.

Additional research resources for the Lehigh University Library, automatically available to the faculty and students of all colleges and universities interconnected with the library.

Faculty fellowships for the pursuit of research in an eighteenth-century topic.

A national Lawrence Henry Gipson Fellowship to be 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.

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, aircrafts, automobiles, bridges and buildings. In

addition, fracture mechanics is finding application in such areas as bone fracture, environmentally enhanced 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 include: expansion of research capabilities to include the application of concepts of fracture mechanics to geology (rocks), medicine (bones), and composite materials; editing books on timely subjects in fracture and solid mechanics; compilation and collection of written materials to establish and maintain a special library of fracture mechanics; planning of conferences on fracture and solid mechanics; offering short courses and seminars on special topics; conducting a liaison program with industry and with 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 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; combine 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.

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: (1) to teach the principles and applications of metal forming technology to graduate and undergraduate students; (2) to provide instruction and equipment for graduate research in metal forming processes; and (3) 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, are supported by University funds, federal funds, and an industrial consortium group.

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.

South Jersey Wetlands Institute

Background and Purpose

This facility is a joint activity between the South Jersey Wetlands Institute, incorporated as a non-profit organization, and Lehigh University. The University operates the institute under the Center for Marine and Environmental Studies at Lehigh.

The South Jersey 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, New Jersey. 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 of the Wetlands Institute for research and education which falls within the general objects of the institute. These objectives 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: 6 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 sub-lethal 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, the future leaders of the country. In conjunction with teacher training, every effort is made to provide lectures, demonstrations and tours of the wetlands for classes. Hopefully, various classroom projects may be developed where students and scientists may work together. Selected undergraduate courses are also offered as part of the summer program.

For further information write to the director, Professor Sidney S. Herman.

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.

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.

Description of Courses

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 pre-registration.

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 his 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 college career, for a total of not more than six hours of credit. He 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 his department must decide whether he may receive credit which will count toward fulfilling requirements for a graduate degree. The apprentice will be graded for his work in the course by his 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 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 instructor teaching or in charge of the course, 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.

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.
Wendell P. Trumbull, Ph.D., C.P.A.

Adjunct Professor

H. Louis Thompson, M.B.A.

Associate Professor

Feng-Shyang Luh, Ph.D.

Assistant Professor

Kenneth P. Sinclair, Ph.D.

Instructors

Stuart K. Webster, M.B.A., C.P.A.
Dunham R. Bainbridge, M.S., C.P.A.

Major in Business and Economics College

Required: 15 credits beyond the core, listed on page 40.

Acctg 315	Financial Accounting (3-4)
	Accounting Electives (except Acctg 390) (11-12)

Major in Arts and Science College

Required Preliminary Courses

Acctg 51, 52	Essentials of Accounting (6)
Eco 1	Economics (4)
Eco 45	Statistical Methods (3)
Math 41	BMSS Calculus I (3)
Math 42	BMSS Probability (3)
Math 43	BMSS Linear Algebra (3)

Required Major Courses

Acctg 111	Computers in Business (3)
Acctg 315	Financial Accounting (3-4)
Eco 129	Money and Banking (3)
Eco 206	Microeconomic Analysis (3)
Law 1	Business Law (3)
Mgt 302	Quantitative Models—Conceptual (3)
	or
Mgt 321	Organization Behavior (3)

Plus nine semester hours of 300-level accounting courses excluding Acctg. 390, Internship.

Note: Students interested in qualifying for the CPA or CMA certificate 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)
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)
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)
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)
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 3 credit hours) course in computers.

For Advanced Undergraduates and Graduates

300. Apprentice Teaching in Acctg. ——— (1-3)

307. Federal Tax Accounting (3)
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.

311. Accounting Information Systems
A general introduction to the development and implementation of an electronic data processing accounting information systems. The course will consider the tools and techniques used by someone performing the systems function. Prerequisite: Acctg. 52 or 108 and Acctg. 111.

315. Financial Accounting (3-4)
Intensive study of theory, generally accepted accounting principles, and problems concerned with presenting fairly the operating results, financial position, and changes in financial position of business entities; preparation, analysis, and interpretation of financial statements. Prerequisite: Acctg. 52 or 108.

317. Advanced Accounting (4)
Problems dealing with business combinations, partnerships, fund accounting as it applies to non-profit entities, fiduciary accounts, insolvent concerns, etc. Prerequisite: Acctg. 52 or 108.

318. Contemporary Issues (2-3)
Intensive study of A.I.C.P.A. pronouncements, research studies, cases, reports, related to current external reporting problems in public accounting. Prerequisite: Acctg. 315.

319. Development of Accounting Principles (3)
A critical and historical survey of the development of accounting principles and theory in the twentieth century. Prerequisite: Acctg. 315.

320. Auditing (3)
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.

324. Cost Accounting (3)
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 in accounting acceptable to the supervising professor and 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 instructor and department chairman.

390. Internship (0-6)
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 MBA 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 certificates, or for the selection of accounting electives, see the chairman, accounting department.

406. Advanced Tax Planning & Research (3)
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.

408. (I.E. 408) Management Information Systems (3)
For description, see I.E. 408.

422. Managerial Accounting (3)
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. 52 or 108.

424. Advanced Management Accounting (3)
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.

431. Accounting Theory and Thought (3)
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)
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. Offered every other year.

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 instructor and department chairman. May be repeated.

American Studies

Joseph Dowling, Ph.D., *Professor of History and Director of American Studies*

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 the student with a greater awareness of the forces which have shaped his world and his character and should produce a greater sensitivity to the values of his 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 his senior year the student will take 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 331	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)

Options

Hist	European History (6)
Engl	European Literature (6)
	Electives (6)

Choice of electives and options to be made in consultation with advisor, selected from such disciplines as economics, fine arts, government, philosophy, religion studies, 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 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.

Recommended Professional Sequences

Beginning with the sophomore year, the arts-engineering student will be guided by the appropriate pattern roster in his 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

154 credit hours needed for B.A. and B.S.

Sophomore Year, First Semester (17 credit hours)

	Language (5)
Math 23	Analytic Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
ChE 41	Cascade Processing Concepts (3)

Sophomore Year, Second Semester (18 credit hours)

	Language (5)
Math 205	Linear Methods (3)
Chem 90	Physical Chemistry (3)
ChE 52	Introduction to Transport Phenomena (4)
	Distribution Elective (3)

Junior Year, First Semester (15 credit hours)

	Language (4)
Chem 191	Physical Chemistry (3)
Chem 192	Physical Chemistry Lab (1)
ChE 167	Unit Operations (3)
ChE 169	Unit Operations Lab I (1)
	Distribution Elective (3)

Junior Year, Second Semester (17 credit hours)

	Language (3)
ChE 170	Unit Operations Lab II (1)
ChE 286	Modelling, Simulation, and Control (3)
ChE 210	Chemical Engineering Thermodynamics (4)
	Distribution Electives (6)

Senior Year, First Semester (17 credit hours)

ChE 302	Chemical Engineering Kinetics (3)
Chem 51	Organic Chemistry (3)
Chem 55	Organic Chemistry Lab (2)
	Electives for Engineering Major (3)
	Distribution Electives (6)

Senior Year, Second Semester (15 credit hours)

ChE 174	Chemical Plant Design (3)
	Electives for Engineering Major (9)
	Distribution Electives (3)

Summer

ChE 100	Industrial Employment

Note: For senior year engineering electives, the student should consult with department of chemical engineering advisors.

Arts-Civil Engineering

155-167 credit hours needed for B.A. and B.S.

Sophomore Year, First Semester (17 credit hours)

	Language (5)
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 (17 credit hours)

	Language (5)
Math	Approved Mathematics Elective (3)*
Mech 1	Statics (3)
	Distribution Electives (6)

Junior Year, First Semester (16 credit hours)

	Language (4)
Mech 11	Mechanics of Materials (3)
CE 13	Civil Engineering Concepts (3)
	Distribution Electives (6)

Junior Year, Second Semester (15 credit hours)

	Language (3)
Mech 102	Dynamics (3)
CE 40	Principles of Surveying (3)
	Distribution Electives (6)

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	Industrial Employment Eight weeks of industrial 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 (17 credit hours)

	Language (5)
Math 23	Analytical 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 (15 credit hours)

	Language (5)
Math 205	Linear Methods (3)
Mech 103	Principles of Mechanics (4)
	Distribution Elective (3)

Junior Year, First Semester (15 credit hours)

EE 11	Introduction to Computer Engineering (3)
Math 231	Statistical Inference
	or
Math 309	Theory of Probability (3)
	Distribution Electives (9)

Junior Year, Second Semester (16 credit hours)

	Language (3)
EE 20	Introduction to Circuit Theory (4)
Phys 31	Introduction to Quantum Mechanics (3)
	Distribution Electives (6)

Senior Year, First Semester (17 credit hours)

EE 105	Electronic Circuits (4)
EE 104	Linear Systems and Signals (4)
	Approved Electives (6)
	Distribution Elective (3)

Senior Year, Second Semester (17 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 (6)

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

150 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

152 credit hours needed for B.A. and B.S.

Sophomore Year, First Semester (17 credit hours)

	Language (5)
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)

Sophomore Year, Second Semester (17 credit hours)

	Language (5)
Math 231	Statistical Inference (3)
IE 18	Information Processing Theory (3)
	Engineering Science Elective (3)
	Distribution Elective (3)

Junior Year, First Semester (16 credit hours)

	Language (4)
Math 205	Linear Methods (3)
IE 205	Engineering Statistics (3)
	Engineering Science Elective (3)
	Distribution Elective (3)

Junior Year, Second Semester (16 credit hours)

	Language (3)
IE 206	Operation Research Techniques (4)
	Engineering Science Elective (3)
	Distribution Electives (6)

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)
	Distribution 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

155-161 credit hours needed for B.A. and B.S.

Sophomore Year, First Semester (17 credit hours)

	Language (5)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
Math 23	Analytic Geometry and Calculus III (4)
	Distribution Elective (3)

Sophomore Year, Second Semester (17 credit hours)

	Language (5)
Mech 1	Statics (3)
Math 205	Linear Methods (3)
CE 11	Engineering Graphics (3)
	Distribution Elective (3)

Junior Year, First Semester (17 credit hours)

	Language (4)
Met 63	Engineering Materials and Processes (3)
	or
Met 91	Elements of Materials Science (3)
ME 101	Mechanical Engineering Design I (1)
ME 104	Thermodynamics I (3)
	Distribution Electives (6)

Junior Year, Second Semester (17 credit hours)

	Language (3)
Mech 11	Mechanics of Materials (3)
Mech 13	Materials Testing Laboratory (1)
Math 208	Complex Variables
	or
Math 231	Statistical Inference (3)
EE 160	Electrical Circuits and Apparatus (3)
EE 161	Electrical Problems (1)
EE 162	Dynamo Laboratory (1)
ME 102	Mechanical Engineering Design II (2)

Senior Year, First Semester (17 credit hours)

ME 105	Thermodyanmics II (3)
ME 108	Laboratory I (2)
Mech 102	Dynamics (3)
Mech 203	Advanced Strength of Materials (3)
	Distribution Electives (6)

Senior Year, Second Semester (16 credit hours)

ME 231	Fluid Mechanics
	or
CE 121	Mechanics of Fluids (3)
CE 123	Fluid Mechanics Laboratory (1)
ME 242	Mechanical Vibrations (3)
ME 109	Laboratory (2)
	Distribution Electives (6)

Summer

ME 100	Summer employment should precede fifth year. Consult department chairman.

Arts-Metallurgy and Materials Science

156-167 credit hours needed for the B.A. and B.S., depending on option selected.

Sophomore Year, First Semester (17 credit hours)

	Language (5)
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)

Sophomore Year, Second Semester (15-16 credit hours)

	Language (5)
Met 10	Metallurgy Laboratory (1)
Mech 1	Statics (3)
EE 160	Electrical Circuits and Apparatus
	and
EE 161	Electrical Problems
	or
Phys 31	Introduction to Quantum Mechanics (3-4)
	Distribution Elective (3)

Junior Year, First Semester (16 credit hours)

	Language (4)
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)

Junior Year, Second Semester (18 credit hours)

	Language (3)
Met 208	Phase Diagram and Transformations (3)
Met 218	Mechanical Behavior of Materials (3)
Chem 196	Physical Chemistry (3)
	Distribution Electives (6)

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 (9)

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 (9)

Summer

Met 100	Industrial employment should precede fifth year. Consult chairman of department.

Note: students selecting Research Option should elect Met. 240, Research Techniques, in the second semester of the senior year.

Biology

Professors

Richard Griffith Malsberger, Ph.D., *Chairman*
Saul Benjamin Barber, Ph.D.
Thomas C. Cheng, Ph.D., *Director, Center for Health Sciences*
Sidney Samuel Herman, Ph.D., *Director, South Jersey Wetlands Institute*
Basil Waldo Parker, Ph.D.

Associate Professors

Bradford Breckenridge Owen, Ph.D.
Hayden Nelson Pritchard, Ph.D.

Assistant Professor

Steven S. Krawiec, Ph.D.
Ann Cali, Ph.D.

Adjunct Professors

Edward John Benz, M.D.
Eugene M. Landis, M.D., Ph.D.
George John Jackson, Ph.D.
Jack B. Pearce, Ph.D.
Kenneth E. Wolf, Ph.D.

The biology department offers students 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 group of courses 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 in graduate biology. Such pre-professional training is purchased 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. The student should, therefore, consider carefully before committing himself to either program. An initial choice of one or the other program is revisable, although this becomes more difficult after the freshman year.

The Bachelor of Arts Major

Required Courses

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	Advanced 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 41	BMSS Probability (3)
Math 43	BMSS Linear Algebra (3)
Chem 21, 22	Chemical Principles & Laboratory (4)
Chem 51, 52, 55	Organic Chemistry & Laboratory (8)
Chem 39	Analytical Chemistry
	or
Chem 194	Physical Chemistry (3)
Phys 13, 14	General Physics and Physics Laboratory (4)

Recommended Sequence of 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	Organic Chemistry (3)
Chem 52	Organic Chemistry (3)
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 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

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	Advanced 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)
Math 41, 42, 43, 44	BMSS Calculus, Probability and Linear Algebra (12)
	or
Chem 21	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Lab (1)
Chem 51	Organic Chemistry (3)
Chem 52	Organic Chemistry (3)
Chem 55	Organic Chemistry Lab (2)
Chem 90	Physical Chemistry (3)
Chem 191	Physical Chemistry (3)
Chem 192	Physical Chemistry Lab (1)
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)

Recommended Sequence of 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, 53, 55	Organic Chemistry and Lab (8)
Math 23	Analytic Geometry and Calculus III (4)
	or
Math 42, 43	Calculus and Linear Algebra (6)
Phys 21, 22	Introductory Physics II and Lab (5)
Chem 90	Physical Chemistry (3)
Biol	Electives (6)
Psych	Elective
	or
Phil	Elective (3)

Junior Year

Chem 191, 192	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)

Undergraduate Courses

21. Principles of Biology (3)
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)
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 3-hour laboratory per week. Graded only pass-fail.

28. Genetics (3)
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.

34. Comparative Vertebrate Anatomy (4)
A course in vertebrate zoology with emphasis on the study of homologous body structures in the various vertebrate classes and their relationship to the functional demands of habit and environment in each class. Detailed dissections of representative vertebrates are made in the laboratory. Two lectures and two laboratory periods each week. Prerequisite: Biol. 21 and 22, or equivalent; sophomore standing.

35. Microbiology (3)
Emphasis on the appearance, physiology, and taxonomy of prokaryotes. Selected subjects pertaining to relations between man and microorganisms. Prerequisite: a laboratory course in biology.

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 the chairman of the department.

231. Natural History and Ecology (3)
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 instructor.

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)
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 instructor. (Offered only in summer session at Lehigh's South Jersey 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.

262. Special Topics in Biology (1-3)
Continuation of Biology 261.

303. Advanced Invertebrate Zoology (3)
A detailed survey of representative invertebrates. Anatomical and histological examination of selected types. Concepts of evolution and speciation. One lecture and two laboratories per week. Prerequisite: two semesters of biology, one with laboratory.

306. Ecology (3)
The basic principles of ecological interrelationships; training in use of analytical keys and reference collections for the identification of plants and animals; field trips for the study of interrelationships of living organisms. Two lectures and one laboratory period or field trip per week. Prerequisite: two semesters of biology, one with laboratory.

309. Aquatic Biology (3)
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 or 22 or equivalent.

313. General Histology (3)
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.

314. Vertebrate Embryology (3)
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.

317. (Geol. 317) Evolution (3)
The origin of species and higher categories with emphasis on animals. Isolating mechanisms, population structure, rates of evolution, extinction. Prerequisite: Biol. 21 or consent of instructor.

320. Cell Physiology (3)
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: consent of instructor or two semesters of biology, at least one with laboratory, and Chem. 52.

322. Animal Physiology (3)
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: consent of instructor or two semesters of biology, at least one with laboratory, and Chem. 52.

324. Animal Behavior (3)
Discussion of the behavior of invertebrates and vertebrates and analysis of the physiological mechanisms responsible for behavioral actions. Emphasis on perception, environmental stimuli, and adaptive value of specific behavior patterns. Prerequisite: consent of instructor or Biol. 21.

331. Non-vascular Plants (3)
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: consent of instructor of Biol. 21.

332. Evolution of Vascular Plants (3)
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: consent of instructor or Biol. 21.

333. Symbiosis (3)
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.

336. Evolution of Land Plants (3)
Comparative study of the ontogenetic and phylogenetic development of plants as they invaded the terrestrial environment. The algae are studied briefly, but stress is placed on the bryophytes and tracheophytes (land plants). The life cycles of representative plants are examined in detail. Two lectures and a laboratory. Prerequisite: Biol. 21 or its equivalent.

341. Biology of Marine Animals (6)
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 in summer session at Lehigh's South Jersey Wetlands Institute.)

353. Virology (3)
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.

361. Sanitary Microbiology (3)
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.

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.

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, capillary circulation, virology, biological oceanography, 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 Sciences.

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 his 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; capillary permeability, porosity and dye cinematography studies; physiology of parasites, physiological ecology of marine symbionts, invertebrate immunobiology, and nucleic acids of microorganisms.

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 equivalent.

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. Offered as required.

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 or its equivalent.

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.

414. Advanced Ecology (3)
Conferences and field work with emphasis in such areas as aquatic ecology, limnology, and fisheries biology. Whenever possible this will include participation in research problems conducted by the Water Resources Council of the Lehigh Office of Research. Prerequisite: consent of the instructor. Offered as required.

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 the instructor. Offered as required.

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, Chem. 371 or equivalent.

417. Marine Ecology (3)
An advanced course in the ecology of the marine environment. Study of the physical and chemical factors, organisms and their interrelations. Ecological theory pertaining to population dynamics and energy flow. Two lectures and one laboratory period per week. Prerequisite: consent of chairman of department.

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 chairman of department.

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.

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.

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 E.M.'s and some independent work at the transmission E.M. Study of current information on cell ultrastructure.

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 laboratory.

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 instructor.

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.

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 instructor.

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 Edward Schiesser, Ph.D.
Fred P. Stein, Ph.D.

Associate Professors

William L. Luyben, Ph.D.
Gary Wayne Poehlein, Ph.D.

Assistant Professors

Marvin Charles, Ph.D.
Anthony J. McHugh, Ph.D.
Leslie H. Sperling, Ph.D.

Lecturers

Jacob Myer Geist, Ph.D.
Abraham Lapin, Ph.D.
Clyde McKinley, Ph.D.

Research Associates

Francis X. Hasselberger, 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, space exploration, 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 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 working in the research, development, and design fields or for teaching.

Recommended Sequence of Courses

Freshman Year *(see p. 45)*

Sophomore Year, First Semester (16 credit hours)

Math 23	Analytical Geometry and Calculus III (4)
Phys 21, 22	Introductory Physics II & Lab (5)
Eco 1	Economics (4)
ChE 41	Cascade Processing Concepts (3)

Sophomore Year, Second Semester (16 credit hours)

Math 205	Linear Methods (3)
Chem 196	Physical Chemistry (3)
ChE 52	Fundamentals of Transport Phenomena (4)
	Electives (6)

Junior Year, First Semester (15–18 credit hours)

Chem 191, 192	Physical Chemistry & Lab (4)
Chem 51, 53	Organic Chemistry & Lab (4)
ChE 167, 169	Unit Operations & Lab I (4)
	GS Requirement (3)
	Elective (3)

Junior Year, Second Semester (17 credit hours)

ChE 286	Modeling, Simulation, and Control (3)
ChE 170	Unit Operations Laboratory II (1)
ChE 210	Chemical Engineering Thermodynamics (4)
	GS Requirement (3)
	Electives (6)

Summer

ChE 100	Industrial Employment

Senior Year, First Semester (15-18 credit hours)

ChE 302	Chemical Engineering Kinetics (3)
	GS Requirement (3)
	Electives (9-12)

Senior Year, Second Semester (15-18 credit hours)

ChE 174	Chemical Plant Design (3)
	GS Requirement (3)
	Electives (9-12)

Note: The lower number of credit hours represents the load required to meet the graduation requirement; the higher represents the normal semester load.

The 30 hours of electives must be taken from the following distribution:

Chemistry	6 hours
Engineering sciences, physics, and mathematics (including Mech. 1 or Mech. 103)	12 hours
Free electives	12 hours

Undergraduate Courses

41. Cascade Processing Concepts (3)
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)
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 laboratory per week.

60. Unit Operations Survey (3)
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.

165. Unit Operations I (4)
A laboratory-related study of the implications of transport phenomena and conservation principles as applied to chemical processing equipment. Two recitations, two laboratory periods per week. Prerequisite: Ch.E. 52.

166. Unit Operations II (4)
A continuation of Ch.E. 165. One recitation, three laboratory sessions per week.

167. Unit Operations (3)
Implications of transport phenomena and conservation principles as applied to chemical processing equipment. Prerequisite: Ch.E. 52.

169. Unit Operations Laboratory I
Laboratory experience in unit operations. Prerequisite: Ch.E. 167 previously or concurrently.

170. Unit Operations Laboratory II
Laboratory experience with steady state and dynamic process operations. Prerequisite: Ch.E. 286 previously or concurrently.

174. Chemical Plant Design (3)
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 professor.

For Advanced Undergraduates and Graduates

200. Chemical Engineering Thermodynamics (3)
Energy relations and their application to chemical engineering. Consideration of flow and non-flow processes, evaluation of the effect of temperature and pressure on thermodynamic properties of ideal and actual fluids: prediction of the heat effects accompanying phase changes and chemical reactions, application to industrial processes. Prerequisites: Ch.E. 51, Chem. 90 or equivalent.

210. Chemical Engineering Thermodynamics (4)
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. Prediction of heat effects accompanying phase changes and chemical reactions. Determination of chemical and physical equilibrium status. Prerequisite: Chem. 90 or equivalent.

286. Modeling, Simulation, and Control (3)
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)
Study of the strategy of chemical process design with emphasis on optimum order of steps, flow diagrams, energy balances, recycle ratios and their effect on the economics of the operation. Survey of methods for ordering equations. Discussion of process optimization for non-linear systems. Effects of uncertainty in process design.

302. Chemical Engineering Kinetics (3)
The application of chemical kinetics to the design and operation of reactors. Interrelations of kinetics, thermodynamics and unit operations in steady or unsteady states. Prerequisites: Ch.E. 166 or 286, Ch.E. 200 or equivalent, previously or concurrently.

312. (Chem. 312, Met. 312) Fundamentals of Corrosion (3)
For description, see Chem. 312.

315. 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.

320. Waste Water Control (3)
The physical processes of importance in the design of industrial waste water treatment facilities. Topics will include sedimentation and filtration processes as well as advanced methods such as adsorption, ion exchange, osmosis, foaming, freezing, and hydrate formation.

321. Fundamentals of Air Pollution (3)
Introduction to the problems of air pollution including such topics as: sources and dispersion of pollutants; sampling and analysis; technology of economics and control processes; legislation and standards. Prerequisite: senior standing in the college of engineering.

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.

351. Mathematical Modeling in Chemical Engineering (3)
Review of physical laws which serve as the basis for mathematical models of physical systems. Representative models for discrete, staged and distributed systems with examples chosen from chemical processing. Numerical solution of algebraic and differential equations with emphasis on chemical engineering systems analysis. Prerequisite: Math. 205 or equivalent and a knowledge of Fortran.

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)
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.

392. (Chem. 392) Polymer Science (3)
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. A term paper based on literature or laboratory work is required. Prerequisite: Chem. 90 or equivalent.

393. (Chem. 393, Met. 343) Physical Polymer Science (3)
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline, 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)
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 at Lehigh University is a department of moderate size active in research and teaching emphasizing the theory of chemical processing operations. The teaching staff consists of eleven senior faculty men 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. degrees 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. Our 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, cyrogenic engineering, and polymer processing are offered on a rotating basis. The individual graduate student builds his program out of these courses plus additional work in mathematics, chemistry, mechanical engineering, physics, and industrial engineering as his 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 his own 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 computer 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

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 occupies the Whitaker Metallurgical and Chemical Engineering Laboratory. In this building some 40,000 ft. of space is available for the research, teaching, and office needs of the department. The building is completely 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. More complete descriptions are available on all of these programs.

Of these, the most completely formulated is the chemical

metallurgy program. Though Ph.D. programs are available, this is basically M.S.-oriented. Graduates from this program 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 support himself by 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 him to enroll for about 10 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. Under this arrangement, the student pays his own tuition which he accumulates from his industrial wage.

There are available within the department several opportunities for financial support for the graduate student. See the Graduate School section for details.

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. 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 4 years.

400. Chemical Engineering Thermodynamics I (3)
Applications of thermodynamics in chemical engineering. Topics include prediction of physical and chemical equilibria, heat effects accompanying solution, flow of compressible fluids, refrigeration including solution cycles, vaporization and condensation processes. Prerequisite: an introductory course in thermodynamics.

401. Chemical Engineering Thermodynamics II (3)
A detailed study of the uses of thermodynamics in predicting phase equilibria in solid, liquid, and gaseous systems. The phase rule; solution theories; uses of equations of state. Theoretical basis and development of equations of state, applications to azeotropic and extractive distillation, multicomponent separations, liquid extraction.

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.

421. Heat Transfer (3)
Analysis of steady and unsteady state transfer. Radiation, vaporization, and condensation. Heat transfer in high velocity flow and in rarified gases. Applications.

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 equation 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)
Equilibrium stage and continuous contact mass transfer operations with emphasis upon distillation, absorption, and extraction. Binary and multicomponent separations.

435. Simultaneous Heat and Mass Transfer (3)
Unit operations involving simultaneous heat and mass transfer. Emphasis on drying, humidification, dehumidification, and condensation in the presence of non-condensable gases.

440. Process Design (3)
Synthesis of flow sheets for various processes, investigation of contributions to overall economy of various alternatives. Evaluation of profitability of alternatives.

441. System Dynamics and Control (3)
Survey of dynamic models for heat exchangers, reactors, distillation columns and other processing units. Principles of dynamic testing using periodic, transient and random signals. Feedforward, adaptive and computer control.

442. System Design (3)
The state space formulation of dynamic systems. Concepts of observability and controllability. The discrete and continuous formulations of the maximum principle. Dynamic programming. Optimization by systematic search.

450. Special Topics (3-12)
An intensive study of some field of chemical engineering not covered in the more general courses. Credit above 3 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)
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. Major emphasis will be given to the use of the computer for the solution of problems selected from a number of scientific and engineering disciplines.

465. Numerical Methods in Engineering (3)
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.

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.

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.

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 3 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.
Charles Stephen Kraihanzel, Ph.D.
Henry Leidheiser, Jr., Ph.D., *Director, Center for Surface and Coatings Research*
John Alexander Manson, Ph.D., *Director of the Polymer Laboratory, Materials Research Center*
Joseph Robert Merkel, Ph.D.
William Edward Ohnesorge, Ph.D.
Robert Stacy Sprague, Ph.D.
James Edward Sturm, Ph.D.
Thomas Edwin Young, Ph.D.

Associate Professors

Alfred James Diefenderfer, Ph.D.
Ned D. Heindel, Ph.D.
Kamil Klier, Ph.D.
Roland William Lovejoy, Ph.D.
Fortunato Joseph Micale, Ph.D.
Donald Morgan Smyth, Ph.D., *Director, Materials Research Center*
John W. Vanderhoff, Ph.D., *Associate Director, Center for Surface and Coatings Research*

Assistant Professors

Matthew Harold Hulbert, Ph.D.
Keith J. Schray, Ph.D.
Gary W. Simmons, Ph.D., *Assistant to the Director, Center for Surface and Coatings Research*
Daniel Zeroka, Ph.D.

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, air craft, petroleum, agricultural chemistry, etc.) and in many of these industries chemists rise to top management positions. Currently many job opportunities are opening up after three years of relative job scarcity, although Lehigh chemistry graduates have had little difficulty in finding jobs.

The undergraduate curriculum in chemistry contains many of the prerequisites for biology, geology, metallurgy, physics, and chemical engineering so that students can easily transfer either way 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 Pre-medical Students)

Suggested biology electives: 21, 22, 35
Suggested chemistry electives: 352, 371, 372, 377, 378, 350 (Clinical Chemistry)
Suggested physics elective: 367
The above electives may be used in place of Math. 205 and German 3.

Materials Chemistry (Polymer, Solid State, Surface)

Suggested physics electives: 31, 363
Suggested chemistry electives: 312, 392, 393, 394, 396, 397
The above electives may be used in place of German 3.

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 3.

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 3.

Chemistry Management

Suggested accounting electives: 108, 315
Suggested law elective: 101
Suggested management electives: 201, 211, 317, 321
Suggested chemistry electives: 392, 397
The above electives may be used in place of Math. 205 and German 3.

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.).

The Bachelor of Arts and the 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. 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. At present candidates for the B.A. degree must obtain proficiency in a modern foreign language. B.S. candidates need take no language courses, although German 3 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 (131 semester hours is considered to be a normal total for the B.S. degree.)

Recommended Sequence of Courses for the B.S. Degree

Freshman Year (See page 45)

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 (16 credit hours)

Chem 52	Organic Chemistry (3)
Chem 54	Organic Chemistry Lab (2)
Chem 90	Physical Chemistry (3)
Ger 3	Elementary German (5) (or approved substitutes)
Math 205	Linear Methods (or approved substitute) (3)

Junior Year, First Semester (14-17 credit hours)

Chem 191	Physical Chemistry (3)
Chem 192	Physical Chemistry Lab (1)
Chem 234	Analytical Chemistry Lab (1)
Chem 302	Inorganic Chemistry (3)
Chem 332	Analytical Chemistry (3)
Chem 358	Advanced Organic Chemistry (3)
	Electives (0-3)

Junior Year, Second Semester (16 credit hours)

Chem 280	Advanced Chemical Experimentation (3)
Chem 308	Coordination Chemistry (3)
Eco 1	Economics (4)
	GS Requirement (3)
	Elective (3)

Senior Year, First Semester (15-18 credit hours)

Chem 382	Electrochemistry and Kinetics (3)
Chem	Elective (2-3)
	GS Requirement (3)
	Electives (6-9)

Senior Year, Second Semester (15-18 credit hours)

Chem 381	Radiation and Structure (3)
Chem	Elective (2-3)
	Electives (9-12)

Note: The lower number of credit hours represents the load required to meet the graduation requirements; the higher the normal semester load.

Chemistry electives: two electives, one of which must have a lab, are to be chosen from the following list:

Chem 303	Nuclear and Radiochemistry (3)
Chem 306	Inorganic Lab (2)
	or
Chem 368	Advanced Organic Lab (2)
Chem 310	Instrumentation Principles I (3)
Chem 312	Fundamentals of Corrosion (ChE 312, Met 312)
Chem 334	Chemical Oceanography (3)
Chem 350	Special Topics (3)
Chem 352	Heterocyclic Compounds (3)
Chem 371	Elements of Biochemistry (Biol 371) (3)
Chem 372	Advanced Biochemistry (Biol 372) (3)
Chem 375	Research Chemistry Lab (3)
Chem 377	Biochemistry Lab (2)
Chem 392	Introduction to Polymer Science (ChE 391) (3)
Chem 393	Physical Polymer Science (ChE 393, Met 343) (3)
Chem 394	Organic Polymer Science (ChE 394) (3)
Chem 396	Solid State Chemistry (3)
Chem 397	Colloid and Surface Chemistry (3)

Undergraduate Courses

21. Introductory Chemical Principles (4)
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.

22. Chemical Principles Lab (1)
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.

23. Earth, Air, Fire, and Water (4)
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.

39. Analytical Chemistry (3)
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.

51. Organic Chemistry (3)
Systematic survey of the typical compounds of carbon, their classification and general relations; study of synthetic reactions. Prerequisite: Chem. 21.

52. Organic Chemistry (3)
Continuation of Chem. 51. Prerequisite: Chem. 51.

53. Organic Chemistry Laboratory (1)
Preparation of pure organic compounds. Prerequisite: Chem. 21.

54. Organic Chemistry Laboratory (2)
Continuation of Chem. 53 with particular emphasis upon aromatic compounds and qualitative organic analysis. Prerequisite: Chem. 53 and Chem. 52, concurrently.

55. Organic Chemistry Laboratory (2)
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.

90. Physical Chemistry (3)
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.

191. Physical Chemistry (3)
Quantum chemistry of bonding and molecular structure. Elements of statistical thermodynamics. Prerequisites: Chem. 21, Math. 23, Phys. 21.

192. Physical Chemistry Laboratory (1)
This course provides a series of laboratory studies which illustrate the various fields of study in experimental physical chemistry. Prerequisite: Chem. 90.

194. Physical Chemistry for Biological Sciences (3)
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.

196. Physical Chemistry (3)
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.

234. Analytical Chemistry Laboratory (1)
Laboratory course: experiments coordinated with and illustrating methods and principles discussed in Chem. 332.

250. Special Topics (3)
Selected topics in chemistry not included in other courses. Prerequisite: consent of the chairman of the department.

280. Advanced Chemical Experimentation (3)
Laboratory course combining techniques of analytical, inorganic, organic, and physical chemistry in the synthesis, purification, and characterization of selected compounds. Prerequisites: Chem. 54, 192, 234, 308, previously or concurrently.

300. Apprentice Teaching in Chem. ——— (1-3)

302. Principles of Inorganic Chemistry (3)
Application of the theories of atomic and molecular structure and of chemical bonding to the periodic relationships and selected descriptive chemistry of the non-transition elements. Prerequisite: Chem. 191 previously or concurrently.

303. Nuclear and Radiochemistry (3)
A broad survey of nuclear science with particular emphasis on aspects of importance to chemistry and biology. Elementary nuclear theory; production, separation and identification of radioactive and stable isotopes; use of isotopes in the study of chemical and biological systems; radiological safety; nuclear engineering. Two lectures and one lecture-laboratory.

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. 302, previously or concurrently.

308. Coordination Chemistry (3)
Continuation of Chem. 302. Introduction to transition metal complex ions and coordination compounds and to the theories of bonding in these substances. The thermodynamics of metal ion complex formation in solution. Kinetics and mechanisms of transition metal complex reactions. Isomerism in complex compounds. Introduction to transition metal organometallic chemistry. Prerequisite: Chem. 302 or its equivalent.

310. Instrumentation Principles I (3)
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 insttumentation. Transducer application to fields of electrical, optical and mechanical measurement. Two lectures and one three-hour laboratory.

311. Instrumentation Principles II (3)
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.

312. (Ch.E. 312, Met. 312) Fundamentals of Corrosion (3)
Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization and passivity. Non-electrochemical corrosion including mechanisms, theories, and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings, alloys, inhibitors and passivators. Prerequisite: Met. 91, Chem. 90 or equivalent or permission of instructor.

332. Analytical Chemistry (3)
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. 51, 90.

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 instructor.

350. Special Topics (3)
Selected advanced topics in chemistry not included in other courses. Prerequisite: consent of the chairman of department.

352. Heterocyclic Compounds (3)
The chemistry of thiophene, pyrrole, furan, pyridine and their derivatives, considered from the viewpoint of recent theories of organic structure and reaction mechanisms. Prerequisite: Chem. 358.

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)
The study of modern theories of reaction mechanisms and their applications to the problems of organic chemistry. Prerequisite: one year of organic chemistry.

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 (3)
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.

372. (Biol. 372) Advanced Biochemistry (3)
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.

375. Research Chemistry Laboratory (3)
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 department chairman.

377. Biochemistry Laboratory (2)
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.

378. Biochemical Preparations (2)
A laboratory course involving the preparation or isolation, purification and identification of chemicals of biological origin. Prerequisite: Chem. 377 and 372, previously or concurrently.

381. Radiation and Structure (3)
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.

382. Electrochemistry and Kinetics (3-4)
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. 90 and 332.

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)
For course description, see Ch.E. 393.

394. (Ch.E. 394) Organic Polymer Science (3)
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 of organic chemistry.

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.

397. Colloid and Surface Chemistry (3)
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. 90 or equivalent.

For Graduates

The department of chemistry offers graduate work leading to both the M.S. and the Ph.D. degrees (the M.S. is not a prerequisite for the Ph.D.); facilities are available for post-doctoral research. Forty-five M.S. and Ph.D. candidates were enrolled in the department in the 1972-73 academic year.

A student may specialize in biochemistry, analytical, inorganic, organic, physical, or polymer chemistry. The department has numerous laboratory facilities and considerable scientific equipment for chemical research as well as a capable faculty which works closely with students in the classroom and in the research laboratory.

The University libraries contain approximately a half-million volumes and currently subscribe to some 6000 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 three or four years of full time residency beyond the bachelor's degree to complete all the requirements for the Ph.D. degree.

During his 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 interest of the various faculty members. From these contacts the student is able to assess critically his own 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 8 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. Current research projects of interest are listed below.

Analytical Chemistry: electron-reduction and oxidation mechanisms of organic compounds; Hammett correlations with electrochemical reduction potentials; analysis in marine environment, luminescence of metal chelates; voltammetry in non-aqueous solvents.

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; nucleases of marine

bacteria; isolation and characterization of antimicrobial substances; physiology and biochemistry of marine bacteria and other microorganisms; denitrification reactions; immobilization of enzymes; sugar phosphate substrate utilization by glycolytic enzymes; mechanism of phosphoglucose isomerase and aldolase; phosphoryl transfer reactions of enzymes; studies on choline acetyl transferase.

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 and pharmacological behavior; chemical models for biochemical reactions; photochemical enolization processes; sulfur bonding in novel heteroaromatic sulfur compounds; biosyntheses involving indole intermediates; synthesis of new heterocyclic systems; synthesis of phosphate esters of biological interest; kinetics and mechanism of phosphate ester hydrolysis.

Physical chemistry: vacuum ultraviolet photochemistry; radiation chemistry; flash photochemistry and kinetic spectroscopy; surface chemistry of metals, semiconductors, and polymers; heterogeneous nucleation phenomena; catalysis; heats of wetting; stability of colloidal dispersions; polymer adsorption; molecular structure and bonding properties of inorganic, organic, and organometallic compounds from vibration-rotation spectra using infrared and Raman spectroscopy; molecular motion in the crystalline state; molecular structure, conformation, and properties of polymers in solution and in the solid state; application of quantum mechanics and statistical mechanics to problems of chemical interest; heterogeneous catalysis; adsorption and chemisorption kinetics; solid state chemistry; point defects in oxides.

Polymer chemistry: synthesis, structure, conformation, and properties of high polymers; transition and viscoelastic behavior; rubber elasticity; behavior of composites and other multi-component systems.

The chemistry department has offices, laboratories, a library, and other research facilities throughout the four floors of Chandler Laboratories; biological chemistry is located in nearby Williams Hall which also houses the biology department. Physical chemistry of surfaces is located in Sinclair Laboratory with the Center for Surfaces and Coatings Research; polymer chemistry is partly in Coxe Laboratory (Materials Research Center) and partly in Sinclair Laboratory. The specialized equipment available in the department for graduate research includes: mass spectrometer, x-ray diffraction spectrometer, single-beam grating infrared spectrometer, Raman spectrograph, nuclear magnetic resonance spectrometer, electron spin resonance, emission spectrographs, atomic absorption spectrometer, spectrofluorometer, phosphorescence spectrometer, infrared Fourier transform, Auger, Mössbauer spectrometers, radiotracer equipment, Geiger and scintillation counters, light scattering photometer, differential refractometer, flash photolysis apparatus, densitometers, preparative and analytical gas chromatographs, ellipsometer, double-beam infrared and ultraviolet-visible recording spectrometers, counting equipment for radioactivity measurements, 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.

In addition to the facilities of the chemistry department, there are several research centers located on the campus that are maintained by the University; see page 71 of this catalog for a listing of the centers and their facilities.

400. Inorganic Chemistry Research (1-4)
Investigation of a problem in inorganic chemistry.

401. Inorganic Chemistry Research (1-4)
Continuation of Chem. 400.

402. Advanced Inorganic Chemistry (3)
Theories of bonding. Group theoretical principles will be utilized in studies of molecular orbital and ligand field theories of bonding. Prerequisite: Chem. 302 or equivalent.

403. Advanced Topics in Inorganic Chemistry (3)
Subjects of contemporary interest in inorganic chemistry, including quantitative treatment of acid-base chemistry in non-aqueous solvents, mechanisms of inorganic reactions, chemistry of organometallic compounds and metal carbonyls, and chemistry of metal chelates. This course may be repeated when a different topic is offered. Prerequisite: Chem. 302 or its equivalent and consent of instructor.

429. Seminar in Inorganic Chemistry (1-6)
Reports and discussions of recent developments in inorganic chemistry.

430. Analytical Research (1-4)
Investigation of problems in analytical chemistry.

431. Analytical Research (1-4)
Continuation of Chem. 430.

432. Advanced Analytical Chemistry (3)
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. Offered alternate years.

433. Advanced Topics in Electrochemistry (3)
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. Offered alternate years.

436. Advanced Methods of Analytical Chemistry (3)
Theory and analytical applications of selected spectroscopic techniques: e.g., luminescence, magnetic resonance, and microwave spectroscopy. Prerequisite: Chem. 381 or Chem. 445, or equivalent. Offered alternate years.

439. Seminar in Physical Chemistry (1-6)
Reports and discussions of recent developments in physical chemistry.

441. Chemical Kinetics (3)
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.

443. (Met. 443) Solid State Chemistry (3)
Crystal structure, diffraction in crystals and on surfaces, bonding and energy spectra in solids, dielectrics, surface states and surface fields in crystals. Prerequisite: Chem. 191 or equivalent.

445. Elements of Physical Chemistry (4)
Quantum chemistry of simple systems, molecular structure and spectroscopy, statistical and classical thermodynamics, and principles of kinetic processes.

449. Seminar in Analytical Chemistry (1-6)
Reports and discussions of recent developments in analytical chemistry.

450. Theoretical Organic Chemistry (3)
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. Offered alternate years.

451. Theoretical Organic Chemistry (3)
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. Offered alternate years.

458. Topics in Organic Chemistry (3)
An intensive study of limited areas in organic chemistry. May be repeated when a different topic is offered.

459. Seminar in Organic Chemistry (1-6)
Reports and discussions of recent important developments in theoretical and applied organic chemistry.

460. Organic Chemistry Research (1-4)
Investigation of a problem in organic chemistry.

461. Organic Chemistry Research (1-4)
Continuation of Chem. 460.

466. Advanced Organic Preparations (2-3)
A laboratory course of instruction in advanced techniques of the preparation of organic compounds.

471. Natural Products (3)
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. Offered alternate years.

473. Seminar in Biochemistry (1-4)
Reports and discussion of current developments in the field of biochemistry.

474. Biochemistry Research (1-4)
Investigation of a problem in biochemistry.

475. Biochemistry Research (1-4)
Continuation of Chem. 474.

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.

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 the chairman of the department.

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.

480. Advanced Biochemical Preparations (1-3)
An advanced laboratory course in the preparation, isolation, purification and identification of biochemically produced materials. Emphasis is placed on materials and procedures of current interest in biochemistry. Prerequisite: consent of the chairman of department.

490. Physical Chemistry Research (1-4)
Investigation of a problem in physical chemistry.

491. Physical Chemistry Research (1-4)
Continuation of Chem. 490.

492. (Ch.E.492) Topics in Polymer Science (3)
For course description, see Ch.E. 492.

494. Quantum Chemistry (3)
Principles and applications of quantum mechanics to chemical problems. Applications to chemical bonding, molecular structure, reactivity and spectroscopy. Prerequisite: Chem. 445 or consent of chairman of department. Offered alternate years.

495. Statistical Thermodynamics (3)
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. Offered alternate years.

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.

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.
Walter H. Graf, 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

Terence John Hirst, Ph.D.
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 man. 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. Special five-year combined programs leading to the degrees B.S. in C.E. and either B.S. in M.E. or B.A. can be arranged. Also, a combined program leading to the degrees B.S. in C.E. and B.S. in Business Administration (five and one-half years), M.B.A. in management science, or M.S. in foreign studies can be arranged.

Engineers, through their professional societies, have urged that the engineering student be educated as a professional man with a sound understanding of his 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 45)

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)

Note: The lower number of credit hours represents the load required to meet the graduation requirements; the higher represents the normal semester load.

Elective opportunities total 15-27 credits, with at least 6 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)
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.

13. Civil Engineering Concepts (3)
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.

40. Principles of Surveying (3)
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.

41. Engineering Surveys (3)
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. Summer session.

100. Industrial Employment
During the summer following the junior year, students are required to spend at least eight weeks in approved office or shop work or on engineering construction. A written report on the shop work or project, outlining the experience obtained is due on return from summer vacation.

101. Computer Methods (1)
Computer programming of problems encountered in civil engineering, predicated on numerical techniques. Prerequisite: Engr. 1.

102. Civil Engineering Proseminar (1)
A study of current civil engineering projects and developments with written reports. At weekly meetings these reports are presented orally in abstract. Prerequisite: senior standing.

103. Special Problems (1-6)
Supervised individual research problems with report. Prerequisite: consent of instructor.

104. Readings in Civil Engineering (1-3)
Study of selected technical papers, with abstracts and reports. Prerequisite: consent of instructor.

106. Structural Design (3)
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)
Hydrostatics, fundamental laws of fluid motion, emphasis on control volume methods. Potential flow, dynamic similitude, boundary layers, pipe flow, and hydrodynamic forces on objects. Prerequisite: Mech. 102 previously or concurrently.

123. Fluid Mechanics Laboratory (1)
Measurement of pressure, velocity and flow rate. Experimental error and test procedures. Exercises in closed conduit flow, open channel flow, and hydraulic machinery. Prerequisite: C.E. 121 or M.E. 231.

143. Soil Mechanics (3)
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)
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. 160 previously or concurrently.

159. Structural Analysis I (3)
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)
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)
Analysis and design of water distribution, waste water, and storm water collection. Water and waste water sources and treatment configuration. Laboratory work in water and waste water evaluation with application to design. Prerequisite: C.E. 121.

200. Engineering Planning (3)
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: junior standing.

203. Professional Development (3)
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, law, and engineering economics applicable to civil engineers. Written and oral reports. Prerequisite: senior standing.

207. Transportation Engineering I (3)
Principles of the design, construction, and maintenance of transportation facilities with emphasis on highways and airports in the areas of geometric, drainage, and pavement design. Properties and performance of materials used. Field trips and design problems. Prerequisites: C.E. 41, C.E. 143.

222. Hydraulic Engineering (3)
Hydraulic measurements, open channel hydraulics, and sediment transport, hydraulic machinery, hydraulic structures, coastal hydraulics. Prerequisite: C.E. 121 or equivalent.

244. Foundation Engineering (3)
Application of the theories and principles of soil mechanics to foundation design. Site investigations 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.

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)
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 or consent of department chairman.

263. Structural Concrete Design (3)
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 or consent of department chairman.

271. Environmental Engineering II (3)
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.

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)
Hydrologic cycle. Precipitation, evaporation, transpiration, infiltration. Ground water. Stream flow, hydrographs, floods. Statistical analysis applied to hydrology. Prerequisite: C.E. 121.

326. Ground Water Hydrology (3)
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.

328. Channel and Oceanographical Hydraulics (3)
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.

332. Ocean Engineering (3)
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.

333. Ocean Engineering Field Investigations (1-3)
Field studies in ocean engineering involving participation in research investigations conducted at sea. Prerequisite: consent of department chairman.

341. Soil Stabilization (3)
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.

342. Experimental Soil Mechanics (3)
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.

343. Seepage and Earth Structures (3)
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.

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 or equivalent.

359. Plastic Analysis and Design (3)
Plastic analysis and design of steel structure. 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)
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)
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 department chairman.

371. Environmental Health Engineering (3)
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: consent of department chairman.

374. Sanitary Engineering Analysis and Operations (3)
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 department chairman.

376. Water Resources Engineering (3)
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.

380. Design Projects (1-6)
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 the campus. The course will be offered both semesters and 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)
Planning and execution of research projects, survey of current research, elements of proposals and budgets. Literature search procedures. Presentation of data, and of written and oral reports. Guidelines for visual aids.

For Graduates

Graduate studies in civil engineering permit the student to build upon the broad background of undergraduate training 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; 23 Ph.D. and 38 M.S. candidates were enrolled in the department in the 1972-73 academic year.

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 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. There is a considerable amount of interdisciplinary research currently underway in the laboratory.

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, the largest in this country, 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 Science 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)
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.

408. Computer Methods in Civil Engineering (3)
Numerical and computer-oriented methods specially applicable to the solution of complex problems arising in various fields of civil engineering. Solutions of well- and ill-conditioned linear and 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.

424. Surface Water Hydrology (3)
The study of quantities in the flow of water in streams. Meterology; hydrographs. Application of statistical analysis and probability to hydrological problems. Drainage basin analysis and planning. Prerequisite: C.E. 121 or consent of department chairman.

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 department 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)
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.

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 department 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)
The origin, composition, and physico-chemical properties of soils and their influence on the engineering properties and behavior of soils; transmission of water in saturated and unsaturated soils; advanced theory of compaction; compression and consolidation; theories of shear strength. Prerequisite: a course in soil mechanics.

444. Advanced Soil Mechanics II (3)
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.

445. Advanced Foundation Engineering (3)
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.

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. Offered on sufficient demand only. 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)
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.

451. Advanced Structural Theory II (3)
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.

453. Structural Members and Frames (3)
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: C.E. 403 and Mech. 415.

454. Plate and Shell Structures (3)
Analysis and design of plates loaded transversely and in their plane. Shear lag; influence surfaces. Buckling and post-buckling behavior of elastic and inelastic plates. Membrane and bending analysis of cylindrical, rotational and hyperbolic-paraboloidal shells. Exact and approximate engineering methods. Design considerations. Prerequisite: consent of chairman of department.

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 3-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)
Analysis and design of steel structures; structural connections; composite steel-concrete systems and other components. Consideration of residual stress; brittle fracture; fatigue strength; fastener systems. Study of current research and application to design practice.

459. Advanced Topics in Plastic Theory (3)
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.

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)
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.

466. Concrete Shell Structures (3)
Analysis and design of various types of concrete shell structures. Folded plates, barrel shells and shells of double curvature. Application of prestressing. Prerequisites: C.E. 403, C.E. 263, and C.E. 365 or equivalent. Desirable preparation: C.E. 454 or Mech. 416.

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)
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.

472. Water Pollution Control Facilities (3)
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.

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.

Assistant Professor

David Kent Silhanek, 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 will 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 will 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 to his 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.

Recommended Electives

Astron 1	The Solar System (3)
FA 5	Fundamentals of Art (3)
FA 3	History of Architecture (3)
Phil 231	Ancient Philosophy (3)
SR 31	Introduction to Anthropology (3)

Greek

Undergraduate Courses

1. Elementary Greek (3)
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)
Continued work in Greek vocabulary, forms, and syntax. Selected readings in Greek prose. Prerequisite: Gk. 1.

3. Intermediate Greek (3)
Xenophon: *Anabasis,* and other works. Grammar review. Prerequisites: Gk. 1 and 2, or one year of entrance Greek.

4. Intermediate Greek (3)
Plato: *Euthyphro, Apology,* and *Crito,* or other dialogues. Prerequisite: Gk. 3.

21. (Hist. 21) Ancient History (3)
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.

50. Greek Literature in English Translation (3)s,
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.

111. Greek Drama (3)
Representative plays of Sophocles, Euripides, and Aristophanes. Literary study of the drama. Prerequisite: Gk. 4.

112. Greek Drama (3)
Continuation of Gk. 111. Prerequisite: Gk. 4.

113. Greek Historians (3)
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)
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.

202. Greek Archaeology (3)
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.

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 the chairman of department.

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.

271. Readings (3)
Intensive reading in one author or in a selected genre. Prerequisites: six hours of courses at the "100" level and consent of chairman of department.

316. Plato (3)
The Republic, and other dialogues. Lectures on classical philosophy. Prerequisites: six hours of courses at the 100-level and consent of chairman of department.

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 chairman of department.

Latin

22. (Hist. 22) Ancient History (3)
Continuation of Gk. 21. The Hellenistic Age. Rome from its origin to 395 A.D.

51. Latin Literature in English Translation (3)
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.

61. Elementary Latin (3)
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)
Selections from Caesar: *The Gallic War.* Prose composition and syntax. Prerequisite: Lat. 61 or 2 entrance units.

63. Nepos and Cicero (3)
Nepos: *de Viris Illustribus;* Cicero's orations and either *de Senectute* or *de Amicitia.* Prerequisite: Lat. 62 or 3 entrance units.

65. Vergil (3)
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 3 entrance units.

166. The Roman Lyric (3)
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 4 entrance units.

168. Latin Drama (3)
Readings of selected plays of Plautus, Terence, and Seneca. Prerequisite: Lat. 65 or at least 4 entrance units.

For Advanced Undergraduates and Graduates

203. Archaeology of Italy (3)
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.

211. Readings (3)
Intensive readings in one author or in a selected genre. Prerequisites: six hours of courses at the "100" level and consent of chairman of department.

212. Readings (3)
Intensive reading in one author or in a selected genre. Prerequisites: six hours of courses at the "100" level and consent of chairman of department.

301. The Roman Republic (3)
The final century of the Roman Republic (133-44 B.C.) studied through a close examination of the original sources in translation. The course gives a broad comprehension of the historical background to the Latin authors of the Roman Republic normally read in secondary school.

302. The Roman Empire (3)
A continuation of Latin 301. The principate of Augustus and the first century of the Roman Empire (44 B.C.-70 A.D.). The course gives a broad comprehension of the historical background to the Latin authors of the Augustan and Silver Age normally read in secondary school.

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 chairman of department.

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 chairman of department.

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 chairman of department.

306. Roman Prose Writers (3)
Selections from Cicero, Tacitus, and Seneca. Prerequisites: six hours of courses at 100-level and consent of chairman of department.

382. Senior Seminar (3)
Continuation of Gk. 381. Prerequisite: consent of chairman of department.

411. History of Latin Literature (3)
A study of Latin literature from the earliest remains of Latin to the age of Cicero. Intensive readings in Latin of selections of representative authors and genres. Prerequisites: six hours of courses at the "300" level or equivalent.

412. History of Latin Literature (3)
Continuation of Lat. 411. The Age of Vergil to the end of Classical Literature. Prerequisite: Lat. 411.

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

Warren Aiken Pillsbury, Ph.D.
Ching Sheng Shen, Ph.D.
John E. Walker, Ph.D.

Assistant Professors

Jacob DeRooy, Ph.D.
Jon Terence Innes, Ph.D.
John Daniel Keefe, M.A.
John R. McNamara, Ph.D.
Robert J. Thornton, Ph.D.
Andrew B. Weintraub, Ph.D.

Adjunct Professors

Reese D. Jones, M.A.
S. Herbert Unterberger, Ph.D.

Instructor

David B. Smith, M.S.

Major in Arts and Science College

Required Preliminary Courses for B.A.

Freshman Year

Eco 1	Economics (4)
Math	Two courses (6)

Required Major Courses

Sophomore Year

Eco 206	Microeconomic Analysis (3)
Eco 219	Macroeconomic Analysis (3)
Eco 45	Statistical Method (3)
Eco 129	Money & Banking (3)

Junior Year

Eco or Fin	Any 300-level course (6)

Senior Year

Eco or Fin	Any 300-level course (6)

Majors in Business and Economics College

Economics Major

Required: 15 credits of economics beyond the core listed on page 40.

Economics Statistics Major

Required: 15 credits beyond the core as follows:

Eco 346	Business Cycles and Forecasting (3)
Eco 347	National Income Analysis (3)
Eco 352	Advanced Statistical Method (3)
Math 44	BMSS Calculus II (3)
Eco	300-level course (3)

Undergraduate Courses

1. Economics (4)
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)
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 and 42, or equivalent.

129. Money and Banking (3)
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.

130. Money and Banking (3)
A course dealing with specific monetary and banking problems with suggested actions to resolve these problems. Prerequisite: Eco. 129.

For Advanced Undergraduates and Graduates

All of the following courses in economics have as a prerequisite Economics 1 or equivalent.

206. Microeconomic Analysis (3)
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)
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 Eco. ——— (1-3)

303. Economic Development (3)
The principal determinants of economic development; economic development in advanced and underdeveloped countries.

305. The Economic Development of Latin America (3)
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.

307. History of Economic Thought (3)
Emergence of economics as a separate discipline. Exposition, comparison, and appraisal of the method and theories of the classical, socialist, Austrian, and neo-classical schools of economists concerning the economic order, valuation, production, price formation and resource allocation, money, banking and credit, business cycles, social welfare, and the role of the state.

308. History of Economic Thought (3)
The development of modern economics by means of the historical and analytical approaches. The objective is to provide an understanding of the nature and the significance of economic science by means of examining contributions of leading economists or schools from Adam Smith to the present.

309. Comparative Economic Systems (3)
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.

310. Economic Evolution (3)
Long term economic growth and social transformation of the United States.

311. Economics of Resource Use (3)
Economic aspects of environmental pollution and conservation will be considered, including benefit-cost analysis of public projects for development of natural resources, policies for controlling the quality of land and water resources, and the relationship between economic activity and environmental quality.

312. Urban Economics (3)
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.

320. Advanced Macroeconomic Analysis (3)
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 consent of department chairman.

332. Monetary-Fiscal Policy (3)
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. 129 or equivalent.

335. Manpower Economics (3)
The structure of the labor force; the theory of wages and employment; the economics of legal and social aspects of the labor market.

336. Business and Government (3)
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.

337. Transportation and Spatial Economics (3)
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 instructor.

338. Labor Market Institutions (3)
The development of the social and legal status of trade unions; the process of collective bargaining; the evolution of modern social welfare programs.

339. International Trade (3)
The theory of international trade; the theory of tariffs; United States commercial policies; the impact of growth and development on the world economy.

340. International Finance (3)
The balance of payments and the theory of disturbances and adjustment in the international economy; international monetary policies.

343. European Economic Integration (3)
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.

346. Business Cycles and Forecasting (3)
A study of economic conditions, involving short-term fluctuations, growth, forecasting and stabilization proposals. Prerequisite: a course in statistics.

347. National Income Analysis (3)
Analysis of income and product aggregated from the point of view of development and structural breakdown, emphasizing sector accounts, savings and investments; and integrated with broad macroeconomic theory. Prerequisite: Eco. 346.

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.

351. Introduction to Mathematical Economics (3)
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 43, Eco. 206 and 219.

352. Advanced Statistical Methods (3)
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.

353. Public Finance: Federal (3)
A course dealing with government expenditures and revenues, the economics of taxation, and government administration.

354. Public Finance: State and Local (3)
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.

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.

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)
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 source of savings. Prerequisite: Eco. 303.

407. History of Economic Thought (3)
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.

415. (Fin. 415) Capital and Interest Theory (3)
See Fin. 415 for course description.

425. Public Finance (3)
Major issues in taxation of income consumption, and capital; principles of government debt management; budgeting and fiscal planning for economic stability and growth.

431. Managerial Economics (3)
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 instructor.

432. Advanced Microeconomic Analysis (3)
A survey of methods of decision-making at the microeconomic level utilizing concepts developed in price theory and econometrics. Prerequisite: Eco. 206 or equivalent.

435. Advanced Topics in Microeconomics (3)
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 the instructor.

436. Advanced Topics in Macroeconomics (3)
Theory of employment, income, and growth. Role of money in theory of output. Policies for economic stability and growth. Prerequisite: consent of the instructor.

437. Labor Economics (3)
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.

438. Labor-Management Administration (3)
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 peace keeping are subjected to critical appraisal. Prerequisite: Eco. 335 or 338 or equivalent.

440. Regional Science-Metropolitan Analysis (3)
A study of the methodology of regional science with emphasis on metropolitan area analysis. A survey of the applications of this methodology to the economic problems of regions and metropolitan areas.

442. Foreign Trade Management (3)
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.

443. Soviet Economics (3)
The theory of central planning. Investment criteria in Soviet-type economies. Repressed inflation and quantitative output planning. Liberman's Economic Reforms. Prerequisite: Eco. 309 or consent of the instructor.

444. Banking and Monetary Policy (3)
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.

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 instructor.

447. Systems of National Accounts (3)
A study of American National Accounts, relating the theoretical analysis to actual and potential measurements; also relation to National Accounts of other countries. Coverage includes national income, input-output, flow of funds, national balance sheet and other systems of aggregation.

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.

454. Forecasting (3)
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.

455. Econometric Methods (3)
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.

456. Mathematical Economics (3)
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 instructor.

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.

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 the chairman of the department.

475. Business Economics Seminar (3)
Independent research for M.S. in Business Economics candidates.

490. Thesis in Economics (6)
Subjects for theses may be selected by consultation with major advisor and approval of chairman of the department and M.A. committee.

Education

Professors

John A. Stoops, Ed.D., *Dean*
Glenn J. Christensen, Ph.D., *University Distinguished Professor*
Alfred J. Castaldi, Ed.D.
Andrew J. Edmiston, Ph.D.
John A. Mierzwa, Ed.D.
Norman H. Sam, Ed.D.
Merle W. Tate, Ed.D.

Associate Professors

Warren M. Davis, Ph.D.
Matthew W. Gaffney, Ed.D.
Charles W. Guditus, Ed.D.
Joseph P. Kender, Ed.D.
Robert L. Leight, Ed.D.
Paul VanReed Miller, Ph.D.
Estoy Reddin, Ed.D.
William B. Stafford, Ed.D.
Elvin G. Warfel, Ed.D.

Assistant Professors

Raymond Bell, Ed.D.
Mary A. Conahan, Ed.D.
Thomas Fleck, Jr., Ed.D.
Margaret C. Grandovic, Ed.D.
James G. Lutz, Ed.D.
David March, Ed.D.
Artis J. Palmo, Ed.D.
Robert R. Panos, Ph.D.
Dennis A. Pickering, Ed.D.
Alice D. Rinehart, Ed.D.
LeRoy J. Tuscher, Ph.D.
Nan Van Gieson, Ed.D.

Adjunct Professors

Nancy Larrick, Ed.D.
Margaret Melchior Seylar, M.A.

Instructors

David Barrett III, M.Mus.
Frederick Baus III, M.A.
Edward J. Crawford, B.A.
Glenny Dunbar, M.A.
Frederic L. Evans, M.Ed.
Dermot M. Garrett, B.Sc.Ed.
James J. Garrigan, M.A.
Audrey L. Gilmartin, B.S.
Frank J. Kidder III, M.Ed.
Carol J. Kinney, B.A.
Mary R. Kleinginna, M.S.Ed.
Paul F. Kram, M.A.T.
Gretchen H. Krasley, M.Ed.
Ella Jane Kunkle, B.A.
Thelma P. Lifland, M.Ed.
Beverly G. Miller, B.A.
John C. Northrup, M.Ed.
Lloyd C. Parker, B.A.
Ruth B. Parr, M.Ed.
Henry J. Schreitmueller, M.A.
Karol Strelecki, M.S.
Joseph Strickland, Jr., B.A.
Robert J. Szabo, M.Ed.
Harry A. Tachovsky, B.S.
Ann Tarola, M.Ed.
George VanDoren, M.A.
Gregory A. Zebrowski, B.S.

Lecturers

Roy C. Claypool, M.Ed.
Alexander L. Crosby, A.B.
George Douris, M.F.A.
James J. Fadule, Ed.D.
Libby J. Falk, Ed.D.
Richard W. Hartmann, Ed.D.
Paul Johnson, M.A.
Donald K. Kirts, Ed.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.
Robert E. Wisser, Ed.D.

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: admission to certification program in career education.

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: admission to certification program. Summers only.

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 instructor.

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 modifying 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.

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.

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.

321. Classroom Practice (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. Prerequisite: consent of dean of School of Education.

323. Intern Seminar (3)
For undergraduate students admitted to certification programs in career education only. For further details, see Educ. 429.

325. Intern Teaching (3-6)
For undergraduate students admitted to certification programs in career education only. For further 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: admission to certification program in career education.

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: admission to certification program.

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 the social restoration interns only.

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.

351. Statistical Methods in Research (3)
The concept of sampling from populations is introduced. Various ways of describing and condensing sample data and drawing inferences about population characteristics are covered. A brief review of mathematics necessary for statistical analysis is included. No special 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: admission to certification program in career education.

381. Educational Systems and Information Processing (3)
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.

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.

391-392. Workshop (3, 5, or 6)
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.

For Graduates

400. Psychological Foundations of Education (3)
Study and practice of methods involved in making a psychological analysis of pupils or classroom situations particularly in relation to school problems.

401. Sociological Foundations of Education (3)
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.

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.

406. Historical Foundations of Education (3)
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.

407. Philosophical Foundations of Education (3)
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.

408. Comparative Education (3)
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.

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)
Theories of personality and adjustment are examined with emphasis on the adjustment processes in an educational setting. Prerequisite: consent of the program director.

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.

413. Theories of Psychological Counseling (3)
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.

414. Child Development (3)
A study of physical, intellectual, emotional, and social aspects of child development as they relate to the elementary schools.

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.

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.

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. The 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 instructor.

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 elementary and secondary schools in the area.

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)
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.

434. Mathematics in Elementary Education (3)

435. Social Studies in Elementary Education (3)

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 problem 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.

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.

446. Learning Disabilities (3-6)
Types of specific learning disabilities and their effects on development and learning; physiological basis of learning and general learning theory; various theoretical approaches; diagnostic and remedial procedures. Can be repeated for credit as a 90-hour practicum with the consent of the program director.

447. Seminar in Reading Research (3)
An advanced course dealing with critical appraisal and discussion of classical and current studies in reading.

449. Children's Literature in Reading Instruction
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.

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.

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.

455. Statistics I (3)
Reduction and description of data. Characteristics of a frequency distribution. Score transformations. Bivariate linear correlation and regression. Statistical inference: tests of hypotheses and estimation of parameters, errors of inference and their control, power of a statistical test. Uses of the normal, *t* and chi-square sampling distributions.

456. Statistics II (3)
Extended applications of the binomial, normal, *t*, and chi-square sampling distributions. The F distribution. One-way and factorial analysis of variance and covariance. Multiple and partial linear correlation and regression. Application of packaged programs for computer analysis of data. Prerequisite: Educ. 455 or consent of the program director.

457. Statistics III (3)
Extensions of the analysis of variance and covariance to the complex designs. Topics include: completely randomized, factorial, incomplete factorial, randomized blocks, nested, and repeated measures designs. Emphasis on experimental design and application of packaged programs for computer analysis of data. Prerequisite: consent of the program director.

458. Computer Applications (3)
Writing and testing computer programs and the use and adaptation of packaged programs; applications in behavioral research and in administration and instruction. Prerequisite: Educ. 456 or 459.

459. Methods of Statistical Inference and Research Design (3)
Review of descriptive statistics; multiple correlation and regression; tests of inference; analysis of variance and covariance; application of packaged programs for computer analysis of data. Prerequisite: Educ. 351 or 455, or consent of the instructor.

460. Group Counseling and Group Processes (3)
Study of group dynamics through critical review of theories. Emphasis on group processes as related to counseling and guidance through class participation and demonstration. Prerequisite: Educ. 483 previously or concurrently.

463. Public School Administration (3)
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.

464. Foundations of Curriculum Construction (3)
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.

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 and universities.

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.

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.

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)
Topics include fundamentals of: matrix algebra, multinormal sampling distribution, multivariate tests of significance and interval estimation, multivariate analysis of variance and covariance, discriminant analysis, classification problems, canonical correlation, introduction to factor analysis. Emphasis in on application. Prerequisite: Educ. 455 and Educ. 456 or consent of program director.

471. Evaluation in Education (3)
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.

472. Psychometric Theory (3)
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 instructor.

473. Advanced Personnel Seminar
An overview of industrial labor relations as a background for a more detailed study of the movement toward the organization of public employees, with special reference to implications for public school administrators; current developments: the meaning and scope of negotiations, the development of grievance procedures, negotiation agreements, and the negotiation process. Prerequisites: Educ. 463, Educ. 478.

474. Seminar in School Building (3)

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.

477. Seminar in School-Community Relations (3)

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.

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.

480. Elementary School Guidance (3)
Study of child development as related to guidance in elementary schools. Analysis of the roles of counselors, teachers, parents, and other specialists and their influence upon the child. Prerequisite: Educ. 482 and consent of the instructor.

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.

482. Philosophy and Principles of Guidance (3)
Introduction of guidance processes in the elementary and secondary schools and higher education. Theoretical foundations, principles, and ethics of guidance are considered together with the functions, services, and organization of a guidance program.

483. Counseling (3)
Intensive examination of theories and techniques of counseling. Students will conduct counseling interviews. Prerequisite: admission to program in counselor education.

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.

485. Elementary School Principal's Clinic (3-6)

486. Secondary School Principal's Clinic (3-6)

487. Counseling and School Psychology Clinic (3-12)

488. School Superintendent's Clinic (3-6)

489. Reading Specialists Clinic (3-12)

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 3 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 will include 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 in selected school systems. Conference hours for students and staff members will be devoted to discussion of work and problems encountered in the schools. Students will be sectioned as follows: Section A, elementary school principals; Section B, secondary school principals; Section C, guidance counselors; Section D, superintendents of schools; Section E, reading specialists; and Section F, specialists in measurements and research.

Electrical Engineering

Professors

Alfred Kriss Susskind, S.M., *Chairman*
John J. Karakash, D.Eng., *Distinguished Professor and Dean of the College of Engineering*
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.

Assistant Professors

Frank H. Hielscher, Ph.D.
Peggy Anne Ota, Ph.D.
Kenneth Kai-Ming Tzeng, Ph.D.

Instructors

Hans R. Gnerlich, M.S.
Donald Lee Talhelm, M.S.

Lecturers

Francis A. Long, B.S., E.E.
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. In addition, the undergraduate program can also serve as a stepping stone into such related areas as bioengineering, computer science, system engineering, or management science.

An undergraduate will eventually determine that his interests lie in one or two directions—such as research, development, design, or management. His ultimate success will depend upon the depth and breadth of his background, the effectiveness with which he can utilize his knowledge, and the keenness with which he can analyze and solve problems. This is one basic assumption upon which the four-year curriculum is based.

The other basic assumption 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. Finally, the undergraduate curriculum 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 will serve him well. 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.

There are two other areas outside of electrical engineering which are a required part of the curriculum. The first of these is the general studies program, common to all engineering curricula at the University. The other area consists of related engineering sciences, and deals with mechanics, thermodynamics, and materials.

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.

The electives in the senior year provide opportunity for tailoring the individual's program according to his interests and goals. Some will use the electives for acquiring additional background in preparation for graduate study, which has become so important as a consequence of the growth in the intellectual content of engineering and science. Others will select terminal 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, or for entry into professional schools such as medicine or management. For example, a program aimed toward the computing sciences might include, in addition to subjects offered in the electrical engineering department, courses taught by the division of information science and the department of mathematics. Individually tailored programs of this nature should be planned through conference with a department advisor. Early planning can do much to maximize benefits.

Recommended Sequence of Courses

Freshman Year *(see page 45)*

Sophomore Year, First Semester (16 credit hours)

EE 11	Introduction to Computer Engineering (3)
Math 23	Analytical 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	Statistical Inference
	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: the lower number of credit hours represents the minimum load required to meet the graduation requirement; the higher number is the normal semester load.

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 materials, thermodynamics, fluid mechanics, or physical chemistry.

11. Introduction to Computer Engineering (3)
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)
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)
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)
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)
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)
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)
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)
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)
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)
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. Electrical Circuits and Apparatus (3)
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. Prerequisites: Math. 23 and Phys. 21.

161. Electrical Problems (1)
A weekly recitation period intended to supplement the material in E.E. 160 lectures and to discuss homework assignments. Prerequisite: E.E. 160 concurrently.

162. Electrical Laboratory (1)
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.

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.

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.

231. Electric and Magnetic Fields (3)
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. General circuit constants. Regulation efficiency. Symmetrical components. System faults. Sequence impedances of transmission lines; transformer banks; metering. Prerequisite: E.E. 106.

234. Power System Analysis II (3)
Steady state and transient power limits of transmission systems; electromechanical characteristics of electrical machines and networks. Prerequisite: E.E. 233.

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.

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.

245. Electromagnetic Theory (3)
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.

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.

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 instructor.

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.

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 automata; 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.

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 instructor.

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.

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.

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.

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 his 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 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; 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 laboratories of the electrical engineering department are located primarily in the James Ward Packard Laboratory of electrical and mechanical engineering. Facilities for experimental work in electronics and communication cover the spectrum through microwave frequencies. Special research facilities, including a shielded room, are available for the study of devices, noise in semiconductor networks, and digital functions. A laboratory with ultra-high vacuum equipment is available for the investigation of semiconductor surfaces and for the preparation of special devices. There are also facilities for oxidation, diffusion, photolithography, metallization, and wire bonding. The department has a PDP-8 minicomputer and a variety of ancillary building blocks.

401. Digital Systems (3)
Principles of machine organization; macro- and micro-programming. Modern concepts and practices in logical design.

403. Design of Executive Systems (3)
Hardware and software desiderata for executive (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.

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.

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.

410. Electronics of Microwave Tubes and Bulk Semiconductors (3)
Ballistic theory of transit-time tubes. Llewellyn-Peterson equations. Free space-charge waves and their interaction with slow wave structures. Transit-time effects and microwave generation in bulk semiconductors.

411. Information Theory I (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.

412. Information Theory II (3)
Channel encoding and decoding problems and development of random coding bounds. Study of sources and channels with memory including the development of channel models and coding theorems. Investigation of source coding with a fidelity criterion. Prerequisite: E.E. 411.

413. Active Networks (3)
Synthesis of active networks to prescribed frequency characteristics. Stability and realizability criteria. Parameter drift effects.

415. Pattern Classification Theory and Applications I (3)
Estimation and classification techniques useful in communication, control, and pattern recognition. Simple decision theory; likelihood ratios, estimation. Bayesian estimation and reproducing densities. Discriminant functions; measures of distance and information. Error-correcting algorithms and stochastic approximation. Examples of the design of fixed and adaptive filters, detectors, and pattern classifiers.

416. Pattern Classification Theory and Applications II (3)
Compound decision theory. Learning without a teacher; Markovian decision processes. Cluster analysis; linguistic models for pattern analysis and description; feature selection. State of art of practical pattern recognition systems. Examples from optical character recognition, adaptive communication and control systems, and picture processing by computer. Prerequisite: E.E. 415.

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.

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.

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.

432. Finite State Machines (3)
Description of sequential behavior; Gedanken experiments; error control; information loss-lessness, iterative systems. Synthesis of sequential machines in canonic forms and as asynchronous circuits. Prerequisite: E.E. 241 or equivalent.

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.

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.

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.

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.

452. Solid State Device Theory I (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.

453. Solid State Device Theory II (3)
Properties of semiconductor surfaces; tunneling theory. Applications to tunnel diodes and field-effect transistors. Prerequisite: E.E. 451.

454. Solid State Device Theory III (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.

457. (M.E. 457) Introduction to Modern Control Theory (3)
See M.E. 457 for description.

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.

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.

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*
Carl Ferdinand Strauch, Ph.D., *Distinguished Professor*

Associate Professors

Peter G. Beidler, Ph.D.
Cloyd Criswell, M.A.
Jack Angelo DeBellis, Ph.D.
Eustace Anthony James, Ph.D.
John F. Vickrey, Ph.D.

Assistant Professors

Addison C. Bross, Ph.D.
Robert C. Cole, Ph.D.
Edward J. Gallagher, Ph.D.
Robert Richard Harson, Ph.D.
George Buchanan MacDonald, Ph.D.
Rosemarie A. Maier, Ph.D.
Albert J. Solomon, Ph.D.

Two majors are offered by the department of English: English literature, and journalism.

English Literature

Literature is a representation of life at the level of man's individual, human dealings with his fellow men. 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 his experience, revealing whatever wisdom and beauty his vision of the universe affords him. 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 may learn how to read thoughtfully and sensitively, he will be taught how to analyze the basic processes of the literary art. His own skill in using the written word will grow as he studies intensively the writings of those who have shown themselves to be the supreme masters of the skill. Above all, he will be challenged to formulate honest reactions to his reading just as writers originally did when confronted by experience; and so, by integrating his own experience with what Matthew Arnold called "the best that has been thought and said," he will come to perceive whatever wisdom and beauty his own enriched vision will afford him. 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)
	and
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 chairman of the departmental undergraduate major committee to ensure adequate breadth of coverage.

Up to six hours related courses in other departments may be substituted with the approval of chairman of department.

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 German, French, and Latin as undergraduates.

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: Eng. 1.

English Literature and Advanced Composition

Students wishing to major in English literature should take as primary 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)
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)
Continuation of Engl. 4. Prerequisite: Engl. 2, 10, 14, or 16.

7. A Study of the Short Story (3)
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)
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)
A survey of English literature from Wordsworth to Auden. Prerequisite: Engl. 2, 10, 14, or 16.

18. The Novel (3)
A study of a selection of novels as noteworthy works of literature. Prerequisite: Engl. 2, 10, 14, or 16.

19. The Novel (3)
Chronological continuation of Engl. 18. Prerequisite: Engl. 2, 10, 14, or 16.

20. American Major Writers (3)
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)
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)
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)
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)
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)
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)
Study of a characteristic theme, mode, topos, or approach in English literature. Prerequisite: consent of chairman of department and Engl. 2, 10, 14, or 16.

92. Special Topics in English (3)
Continuation of English 91. Prerequisite: consent of chairman of department 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.

151. Introduction to Film (3)
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 of department.

181. Undergraduate Thesis (3)
Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of chairman of department.

182. Undergraduate Thesis (3)
Continuation of Engl. 181. Prerequisite: consent of chairman of department.

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 of department.

184. Readings in English Literature (3)
Continuation of Engl. 183. Prerequisite: consent of chairman of department.

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. Rather it is to instruct and train the student in the methods by which he may pursue the advanced study of literature and literary history. It is to train him in the techniques of criticism and research, so that he may go beyond what has already been done and make an original contribution in his 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 his 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 1972-73, 22 Ph.D. and 70 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.

Beginning with the academic year of 1973-74, master's degree candidates who do not wish to continue for the Ph.D. may, as an alternative option, receive a terminal 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 his needs and interest make it desirable for him 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 his previous preparation, six hours in Old English alone.

For the doctoral examination each candidate will select 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 his 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 were to teach a course in the subject. The three areas may not overlap—except for, in certain circumstances, the third.

315. Early American Literature (3)
A survey of American literature up to the Romantic period.

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.

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)
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 of department.

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)
American literature before World War II. Lectures and class discussion of major fiction and poetry.

322. Twentieth-Century European Literature (3)
English and Continental literature before World War II. Lectures and class discussion of major fiction and poetry.

323. Shakespeare and the Elizabethan Drama (3)
The development of the English drama, including the important plays of Shakespeare.

324. Shakespeare and the Elizabethan Drama (3)
Continuation of Engl. 323.

325. English Literature of the Romantic Era (3)
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.

326. English Literature of the Victorian Era (3)
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.

331. Milton (3)
The life and works of John Milton in connection with the history of his times and chief sources of his inspiration.

333. Restoration and Augustan Literature (3)
Prose and poetry from 1660 to 1745, with special emphasis upon the works of Dryden, Pope, and Swift.

334. Age of Johnson (3)
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.

335. History of the English Language (3)
A survey of the development of the English language, in vocabulary, pronunciation, and structure, beginning with its relation to the other Germanic languages and coming down to modern English usage.

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)
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.

338. The Seventeenth Century (3)
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.

339. Chaucer (3)
Reading and critical study of the chief works of Geoffrey Chaucer, with attention to his language and the backgrounds of his works.

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)
American literature since World War II. Lectures and class discussions of new writers and of recent works by established writers.

342. Contemporary European Literature (3)
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)
A study of the chief American Romantics, Emerson, Thoreau, Whitman, Hawthorne, Melville, and Emily Dickinson. The European and American philosphical, historical, and social background as well as the formal aesthetic study of romantic masterpieces.

344. American Realism (3)
The rise of realism in prose and poetry in the period roughly from the 1870's to 1914; Twain, Howells, James, Robinson, Norris, Crane, Dreiser, and others.

345. Themes in American Literature (3)
An intensive study of a selected topic in American literature, primarily for American Studies majors. Readings range from the colonial period to the present. Sample topics: the American re-discovery of Europe; the theme of apocalypse; American humor; the Edenic motif; personal revolt and social protest. Prerequisite: consent of director of American Studies.

346. Middle English Literature (3)
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.

For Graduates

400. Old English (3)
A study of the Old English language and literature.

401. Beowulf (3)
A study of the Beowulf poem and some of the pertinent scholarship.

404. Literature of the Fourteenth Century (3)
Types of medieval literature, with special attention to Langland, Gower, and the Pearl Poet.

405. Chaucer (3)
A study of the life and works of Chaucer. Readings, reports and class discussions.

406. Chaucer (3)
Continuation of Engl. 405.

407. Middle English Metrical Romances (3)
A study of the Middle English non-Arthurian verse romances.

408. Arthurian Literature of the Middle Ages (3)
A study of the development of Arthurian literature from its Celtic beginnings to Malory's *Morte Darthur.*

412. Shakespeare's History Plays (3)
A study of the English history plays as an introduction to advanced work in Shakespeare.

413. Shakespeare's Roman Plays (3)
An intensive critical study of *Julius Caesar, Antony and Cleopatra,* and *Coriolanus.*

414. Sixteenth-Century Drama (3)
A study of plays representing the development of English drama before Shakespeare.

415. Seventeenth-Century Drama (3)
A study of representative plays from the major Jacobean and Caroline dramatists.

418. Donne (3)
A study of the complete body of Donne's verse, with especial concern for its meanings.

444. Pope (3)
A study of the works of Pope and their literary background.

447. Eighteenth-Century Prose (3)
Studies in periodical prose, philosophical prose, satire, and the development of the novel.

448. Studies in the Eighteenth Century (3)
Studies in, and reports on, one or more authors or issues in eighteenth-century English literature.

452. Keats (3)
A study of the life and works of John Keats. Readings, reports, and class discussions.

457. Carlyle and Arnold (3)
The major works of Carlyle and Arnold contrasted and compared in terms of Romanticism and Victorian social and religious problems.

461. Conrad (3)
A study of Conrad's major novels and tales, with emphasis on the author's style, technique, and attitude.

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.

472. Transcendentalism, Hawthorne, and Emerson (3)
Representative works of the Transcendentalist movement; the major works of Hawthorne and Emerson contrasted and compared in terms of Transcendentalism and Romanticism.

473. Melville and Whitman (3)
The major works of Melville and Whitman contrasted and compared in terms of Romantic doctrine.

477. Twain and James (3)
Selected works of Twain and James representing the development of American fiction after the Civil War.

480. Hemingway and Faulkner (3)
A thematic and stylistic examination of the major works of Hemingway and Faulkner.

486. Literary Criticism (3)
A course aimed to correlate and unify the student's previous work in literature by means of wide reading in critical literature and discussions of theories and schools of criticisms.

487. Literary Criticism (3)
Continuation of Engl. 486.

490. Special Topics (3)
Selected topics in the field of English not covered in other courses. May be repeated for credit. Prerequisite: consent of chairman of department.

491. Special Topics (3)
Selected topics in the field of English not covered in other courses. May be repeated for credit. Prerequisite: consent of chairman of department.

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.

495. Graduate Seminar (3)
An intensive study of the works of one or more English or American authors or of a type of literature.

496. Graduate Seminar (3)
An intensive study of the works of one or more English or American authors, or a type of literature. Subject and instructor vary from semester to semester according to the needs of the students and the wishes of the department. Courses available are Johnson's Literary Criticism (Mr. Dilworth), Approaches to the Short Story (Mr. Frakes), Approaches to Poetry (Mr. Greene), Approaches to Composition (Mr. Hartung), Shakespeare for Teachers (Mr. Hook), Seventeenth-Century Drama (Mr. Hook), Wordsworth (Mr. Harson), Southern Writers of the Twentieth Century (Mr. DeBellis).

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.

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.

1-10. Brown and White (1 or 2)
Enrollment constitutes membership on the staff of the semiweekly paper. Students enrolling for their first semester register for Journ. 1; for their second semester, Journ. 2, etc. Prerequisite: consent of chairman of department.

11. News Writing (3)
Definition, determinants, and components of news; news story structure and style; sources; interviewing; practice in gathering and writing news.

12. Reporting of Public Affairs (3)
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.

17. Magazine Article Writing (3)
Writing and marketing non-fiction magazine articles.

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 instructor and Engl. 2, 10, 14, or 16.

22. Creative Writing (3)
Continuation of Journ. 21. Prerequisite: consent of instructor and Engl. 2, 10, 14, or 16.

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)
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 morgue. Prerequisite: Journ. 11.

115. Interpretive Writing (3)
Editorial interpretation of current events; practice in interpretive writing, including editorials. Prerequisite: Journ. 12.

118. History of American Journalism (3)
English background of the American newspaper; development of press from Colonial days to the present; influence of newspaper on American life; contributions of outstanding journalists.

120. Journalism Proseminar (3)
Survey of the press in its relation to public affairs. Extensive research and reports. Prerequisite: consent of chairman of department.

121. Law of the Press (3)
Constitutional development of freedom of the press; rights and responsibilities of the press.

122. Law of the Press II (3)
Law of and defenses in libel; privacy; contempt; copyright; obscenity.

Division of Speech and Dramatics

Associate Professors

John Pearson, M.F.A., *Head*
Thoburn Vail Barker, M.A.

Assistant Professor

Marshall L. Kaufman, M.A.

Instructor

John A. Schnaible, M.A.

Speech Clinic

For the purpose of diagnosis and treatment of speech defects. Individual instruction provided for students with minor disturbances of voice and speech, as well as those with more serious handicaps. Open to all students in need of corrective treatment and to those desiring speech tests. By appointment. No credit.

Undergraduate Courses

11-13. Basic Production (1)
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)
A foundation course designed to develop knowledge of the basic principles of speech and ability to speak effectively on the platform.

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)
The technique of investigation, analysis, evidence, inference, briefmaking, and refutation in oral argument; participation in the various forms of discussion—conference table, panel, and symposium—and in various types of debate—conventional, cross-examination, and direct clash. Prerequisite: consent of division head.

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. Members required to participate in the activities of the Debate Society. Students enrolling for their first semester register for Speech 34; for their second semester, Speech 35, etc. Prerequisite: consent of the head of the division.

41. Basic Techniques of Acting (3)
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)
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 Speech 41.

45. Basic Design and Technical Theatre (3)
Study and practice of design concepts for the theatre designer. Includes history of theatre architecture.

46. Lighting (3)
Emphasis on the elements of creativity and their translation into the practice of stage lighting. Prerequisite: consent of division head or Speech 45.

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.

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)
The practical technique and production of plays; acting, stage-lighting, scenic design and execution, and student direction of plays. Each member must write either an original one-act play or a thesis upon any practical problems of the modern theatre.

62. Theatre Production (3)
Continuation of Speech 61. Prerequisite: Speech 61.

144. Basic Directing (3)
Survey of theatrical direction. Study of the emergence of the director. Prerequisite: consent of division head or Speech 41.

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.

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)
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. Offered in alternate years.

302. History of the Theatre (3)
Continuation of Speech 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. Offered in alternate years.

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.

346. The Demagogue (3)
Demagoguery from classical times to the present. The role of the demagogue in creating opinion. Prerequisite: consent of division head.

Environmental Sciences & Resource Management

J. Donald Ryan, Ph.D., *Chairman of Geological Sciences and Director of Environmental Sciences & Resource Management Program*

Society's increasing demands for energy, food, recreational opportunities, and living space have altered and will continue to alter the environment of the earth. The need for personnel trained to evaluate proposed alterations and repair existing deleterious or critical situations can only be met by an interdisciplinary approach.

This is an interdepartmental major fostering basic preparation for advanced study and/or an immediate career in environmental management and conservation. The backgrounds of fundamental mathematics and science required to understand the complex of man and his environment is established early within this major, and in the later phases latitude is available for courses of study leading to an understanding of the various aspects of the conflicts of society. Basic principles of ecology are used as the core of the program.

Individual programs can be arranged to provide either a major concentration on a specific phase of environmental problems, i.e., water pollution, air pollution, solid waste disposal, or land planning. Programs can be developed to create a broad awareness and knowledge of the total environment. Student research into specific problems involving laboratory, field, or library research is an integral part of the recommended program.

Graduates of this major can expect to take part in planning, education, research and coordination of environmental programs for all levels of government, schools, and industry. As graduate study is advisable for students contemplating some of these career areas, the program provides thorough preparation for further study in specific areas of environmental sciences.

Program for Bachelor of Science Degree

College and University Requirements (50 credit hours)

Engl 1	Composition and Literature (3)
Engl 2, 10, 14, or 16	Composition and Literature (3)
	Electives (39)

Note: Elective courses are non-professional 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 Major 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)
Chem 21	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Lab (1)
Chem 39	Analytical Chemistry (3)
Chem 51	Organic Chemistry (1)
Chem 53	Organic Chemistry Lab (1)
Geol 1	Principles of Geology (3)
Geol 211	Environmental Planning (3)
Geol 281	Geological Research (3)
Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Lab (1)
Biol 35	Microbiology (3)
Biol 361	Sanitary Microbiology (3)
Biol 306	Ecology (3)
CE 271	Environmental Engineering II (3)
ChE 52	Transport Phenomena (4)
Engl 142	Technical Writing (3) (or equivalent)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
	Plus four courses from the following list (12 credit hours):
Biol 303	Advanced Invertebrate Zoology (3)
Biol 317	(Geol. 317) Evolution (3)
ChE 320	Waste Water Control (3)
ChE 321	Fundamentals of Air Pollution (3)
CE 121	Mechanics of Fluids (3)
CE 170	Sanitary Engineering I (3)
CE 326	Ground Water Hydrology (3)
CE 325	Hydrology (3)
CE 332	Ocean Engineering (3)
CE 371	Environmental Health Engineering (3)
CE 162	Environmental Engineering (3)
CE 222	Hydraulic Engineering (3)
Eco 311	Economics of Resource Use (3)
Geol 313	Sedimentology (3)
Geol 363	Introduction to Oceanography (3)
Geol 212	Geomorphology and Surficial Geology (3)
Govt 360	Public Administration (3)
Spch 30	Fundamentals of Speech (3)
Chem 196	Physical Chemistry (3)
Chem 191	Physical Chemistry (3)
Mech 1	Statics (3)
Mech 102	Dynamics (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)
	Electives (3)

Freshman Year, Second Semester (15 credit hours)

Math 22	Analytic Geometry and Calculus II (4)
Phys 11, 12	Introductory Physics I & Lab (5)
Engl 2, 10, 14, or 16	Composition and Literature (3)
	Electives (3)

Sophomore Year, First Semester (16 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Phys 21, 22	Introductory Physics II & Lab (5)
Geol 1	Principles of Geology (3)
Chem 51, 53	Organic Chemistry & Lab (4)

Sophomore Year, Second Semester (16 credit hours)

Biol 21, 22	Principles of Biology & Lab (4)
Chem 39	Analytic Chemistry (3)
	Electives (9)

Junior Year, First Semester (15 credit hours)

Geol 211	Environmental Planning (3)
Biol 361	Sanitary Microbiology (3)
Engl 142	Technical Writing (or equivalent) (3)
	Electives (6)

Junior Year, Second Semester (16 credit hours)

Biol 306	Ecology (3)
Biol 35	Microbiology (3)
ChE 52	Transport Phenomena (4)
	Electives (6)

Senior Year, First Semester (15 credit hours)

CE 271	Environmental Engineering II (3)
	Electives 12

Senior Year, Second Semester (15 credit hours)

Geol 281	Geological Research (3)
	Electives 12

Fine Arts

Professors

Richard J. Redd, M.F.A., *Chairman*

Associate Professor

Carlos J. Alvare, M. Arch., M.C.P.

Assistant Professors

Leon N. Hicks, Jr., M.F.A.
Donald D. Schneider, Ph.D.

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 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 in designed for those who wish to pursue this area of the humanities as a professional art historian.

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 travelling distance facilitate the first-hand study of art.

An intercollegiate exchange with the art department of Moravian College permits fine arts majors to take courses offered on both campus. Cross-listed courses are indicated.

General Art Major (39 credit hours)

Required Preliminary Courses (12 credit hours)

FA 5	Fundamentals of Art (3)
FA 10	Color and Design (3)
FA 11	Drawing and Graphics (3)
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, one at the advanced level (18)

Pre-Architecture Major (52 credit hours required)

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 10, 11, 23	One studio course in drawing or design (3)

Required Major Courses (30 credit hours)

Mech 1	Statics (3)
Mech 11	Mechanics of Materials (3)
CE 106	Structural Design (3)
CE 159, 160	May be substituted in some programs (6)
FA 43	Environmental Design (3)
FA 143	Environmental Planning and Project (3)
FA 144	Intermediate Environmental Design (3)
FA 244	Architectural Design (6)
FA 220	20th Century Art (3)
FA 151	History of Urban Design (3)

Art History Major (36 credit hours required)

Required Preliminary Course

FA 5	Fundamentals of Art (3)

Required Major Courses

	One of the following:
FA 10	Color and Design (3)
FA 11	Drawing and Graphics (3)
FA 23	Life Drawing (3)
Art 75	Ceramics I (Moravian) (3)
	One of the following:
Gk 201	Archaeology of the Near East (3)
Gk 202	Greek Archaeology (3)
Lat 203	Archaeology of Italy (3)
SR 31	Introduction to Anthropology (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)
Art 105	Ancient Art (Moravian) (3)
Art 110	Medieval Art (Moravian) (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; C.E. 150; Govt. 357; Geol. 211.

Undergraduate Courses

3. History of Architecture I (3)
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.

4. History of Architecture II (3)
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.

5. Fundamentals of Art (3)
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. Color and Design (3)
Basic color theory, painting practice. Principles of design and composition in two and three dimensional media. Individual projects are directed toward developing creative expression. Studio.

11. Drawing and Graphics (3)
Methods, media and concepts of drawing. Practice in representing 3-dimensional form. First principles in printmaking. Studio.

23. Life Drawing (3)
Drawing from the life model as the fundamental experience for acquiring control of hand and eye essential to good draftsmanship. Prerequisite: consent of chairman of the department.

33. Painting (3)
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 of the department.

37. Printmaking (3)
Independent practice in graphic techniques. Emphasis on intaglio, with introductory studies of and combination of two additional methods of printmaking. Prerequisite: F.A. 11.

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: engineering or architectural drawing; or field experience; or consent of instructor.

75. Ceramics I (3)
Elementary problems in the basic techniques of hand-built and wheel-thrown pottery. Moravian College campus.

105. Ancient Art (3)
The art of Egypt, Mesopotamia, Greece, Etruria and Rome. Moravian College campus.

110. Medieval Art (3)
The art of the periods of Early Christian, Byzantine, Carolingian, Romanesque, and Gothic. Moravian College campus.

115. Italian Renaissance Art (3)
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.

117. Baroque and Rococo Art (3)
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.

123. Advanced Life Drawing (3)
An advanced course in drawing from the live model. Prerequisite: F.A. 23. May be repeated for credit.

133. Intermediate Painting (3)
Problems in oil, watercolor, acrylic and mixed media. Prerequisite: F.A. 33. Lehigh and Moravian College campuses.

137. Intermediate Printmaking (3)
Studies of any combination of two methods of printmaking, stressing experimentation and creative application of the materials and tools of graphics. Prerequisite: F.A. 37. Lehigh and Moravian College campuses.

143. Environmental Planning and Project (3)
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.

144. Intermediate Environmental Design (3)
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 instructor.

145. Structure in Architecture (3)
Introduction to structural forms and systems; directed toward an understanding of various structural elements. Vocabulary of structural terms. Prerequisite: consent of the instructor or Mech. 1.

151. History of Urban Design (3)
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 the chairman of department.

152. Physical Planning and Design (3)
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.

175. Ceramics II (3)
Problems in wheel-throwing construction and decoration. Emphasis on creative expression and experimentation. Prerequisite: F.A. 75. Moravian College campus.

176. Ceramics III (3)
Individual problems in thrown and hand-built pottery. May be repeated for credit. Prerequisite: F.A. 175. Moravian College campus.

200. 20th Century Architecture (3)
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.

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)
From Neoclassicism through the sequential movements of Romanticism, Naturalism, Impressionism and Post-Impressionism in the art of Europe and the U.S.

220. 20th Century Art (3)
Sequential movements in contemporary painting and sculpture. Their interrelations as cultural expression. Museum reports and critical interpretation.

233. Advanced Painting (3)
Provides creative work in depth in a variety of painting media. Prerequisite: F.A. 133 or consent of chairman. May be repeated for credit. Lehigh and Moravian College campuses.

237. Advanced Printmaking (3)
Intaglio and one additional method of printmaking. Emphasis on experimentation and application of mixed media in graphics. Prerequisite: consent of department chairman or F.A. 137. Lehigh and Moravian College campuses. May be repeated for credit.

244. Architectural Design (1-3)
Individual study, project or other assignment for advanced students or majors capable of progress beyond general course content or requirement. Content organized by intructor and chairman of department. Conferences and critiques. May be repeated for credit. Prerequisite: consent of chairman of department.

271. Readings (3)
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 the department chairman.

273. Special Topics in Studio Practice (1-4)
Individually directed projects for advanced students capable of undertaking independent creative work in applied art. Prerequisite: consent of chairman of the department.

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 E.E. degree is conferred on the completion of the fourth year, and the E.P. degree at the end of the fifth year.

Freshman Year (See page 45)

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	Statistical Inference (3)
	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)
	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 (3)
	or
Phys 213	Electricity and Magnetism II (3)
Phys 215	Particles & Fields I (3)
EE	Departmental Electives (3)
	GS Requirement (3)
	Elective (0-3)

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	Heat, Thermodynamics & Pyrometry (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; and Met. 362.

Industrial Engineering and Business

Students who desire to pursue both industrial engineering and business administration may complete the required work for the degree of bachelor of science in industrial engineering by the end of the fourth year and that required for the degree of bachelor of science in business and economics by the end of the fifth year. The first four years are essentially the standard industrial engineering curriculum.

At the beginning of the fifth year the student transfers to a curriculum in business and economics and is required to complete thirty-three semester hours by selecting a standard major in the College of Business and Economics, completing the 15 to 18 credit hours required for the major. The balance of his program in the fifth year will be selected in consultation with his advisor from those college core requirements which he has not already taken for the B.S. in Industrial Engineering.

Freshman Year (See page 45)

Sophomore Year (Same as Industrial Engineering)

Junior Year, First Semester (18 credit hours)

IE 101	Fundamentals of Manufacturing Engineering (4)
IE 205	Engineering Statistics (3)
Math 205	Linear Methods (3)
	Engineering Science Elective (3)
	GS Requirement (3)
Eco	Any Course (3)

Junior Year, Second Semester (18 credit hours)

IE 102	Work Systems (3)
IE 206	Operation Research Techniques (4)
	Engineering Science Elective (6)
	GS Requirement (3)
Eco 335	Manpower Economics (3)

Those students who will major in accounting in the fifth year will take Acctg. 51, 52, 215, and one 300-level Accounting course (excluding Acctg. 390, Internship) in their junior and senior years instead of Acctg. 108, Mkt. 211, Fin. 225, and Eco. 335.

Senior Year, First Semester (18 credit hours)

Acctg 108	Fundamentals of Accounting (3)
IE	Electives (6)
	Engineering Science Elective (3)
Engl	Elective (3)
Mkt 211	The American Marketing System (3)

Senior Year, Second Semester (18 credit hours)

IE 154	Project (3)
IE	Electives (9)
Engl	Elective (3)
Fin 225	Business Finance (3)

Majors in personnel and industrial relations must pursue the following program for the fifth year:

Required Courses

Fifth Year, First Semester (9 credit hours)

Law 101	Business Law (3)
Eco 129	Money and Banking (3)
Psych 201	Industrial Psychology (3)

Fifth Year, Second Semester (12 credit hours)

Eco 206	Microeconomic Analysis (3)
Eco 338	Labor Market Institutions (3)
SR 11	Sociology (3)
Eco 346	Business Cycles (3)

and twelve credit hours from the following:

Fin 323	Investments (3)
Fin 353	Public Finance: Federal (3)
Fin 340	International Finance (3)
Eco 347	National Income Analysis (3)
Eco 371	Readings in Economics (3)
Eco 352	Advanced Statistical Method (3)
Law 102	Business Law (3)
Govt 360	Public Administration (3)
Eco 372	Readings in Economics (3)
IE 334	Organizational Planning and Control (3)
Mgt 321	Organization Behavior (3)
SR 65	Contemporary Problems in Society (3)

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, twenty-one to 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, or GRE exam.

For background courses required for the M.B.A., engineering students should see graduate study in business and economics, and consult with assistant dean of the college, Max D. Snider.

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 B.A. 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 M.B.A. degree must also be completed.

For background courses for the M.B.A., students should see graduate study in business in economics, and consult with assistant dean of the college, Max D. Snider. Many of the background courses can be rostered in the student's arts curriculum.

B.S. Engineering—M.S. Materials

A special program leading to an M.S. degree in materials is offered for engineering graduates who complete prerequisite courses in physical chemistry, metallurgy, mechanics, etc. Careful selection of technical electives by interested Lehigh undergraduate students can provide for the required prerequisite courses in typical engineering B.S. degree programs; alternately, for other students, the prerequisite courses are taken before proceeding with the program. This program is intended to give in-depth training in one of the normal engineering disciplines during four years, combined with an understanding of materials behavior in graduate study in approximately 15 months. While intended primarily as a terminal degree for those entering industry, the M.S. in materials provides sufficient flexibility to permit those interested in a career in materials research to continue for a Ph.D. degree.

A schedule of prerequisite courses together with recommended electives and a typical graduate program for mechanical engineers is given below. Graduate programs for other engineering disciplines can be developed by consultation with the appropriate department advisor and the director of the Materials Research Center.

Prerequisite Courses

Science Orientation (21 credit hours)

Met 91	Elements of Materials Science (3)
Chem 196	Physical Chemistry (3)
Met 210	Metallurgical Thermodynamics (3)
Met 361	Physics of Materials (3)
Met 362	Structure and Properties of Materials (3)
	Electives (6)

Engineering Orientation (21 credit hours)

Met 63	Engineering Materials and Processes (3)
Chem 196	Physical Chemistry (3)
Met 207	Electronic & Crystal Structure (3)
Met 208	Phase Diagrams & Transformations (3)
Met 210	Metallurgical Thermodynamics (3)
Met 218	Mechanical Behavior of Materials (3)
	Electives (3)

Note: An alternative to Chem. 196 is Chem. 91 and Chem. 190.

Recommended Electives for Preparatory Program

Structure of Solids Group

Met 315	Introduction to Physical Ceramics (3)
Met 316	Physical Properties of Materials (3)
Met 317	Imperfections in Crystals (3)
Met 333	X-ray Methods (3)
Met 334	Electron Metallography (3)
Met 343	Physical Polymer Science (3)
Geol 333	Crystallography (3)
Phys 362	Atomic and Molecular Structure (3)

Phys 363	Physics of Solids (3)
Math	Approved Elective (3)

Physical Metallurgy Group

Met 307	Structure & Behavior of Materials (3)
Met 315	Introduction to Physical Ceramics
Met 316	Physical Properties of Materials (3)
Met 317	Imperfections in Crystals (3)
Met 313	Materials Fabrication (3)
Met 333	X-ray Methods (3)
Met 334	Electron Metallography (3)
Math	Approved Elective (3)
Met 358	Selection of Materials (3)

Mechanics & Mechanical Behavior Group

ME 166	Procedures for Mechanical Design (2)
Mech 313	Fracture Mechanics (3)
Met 313	Materials Fabrication (3)
Met 317	Imperfections in Crystals (3)
Math	Approved Elective (3)

Chemical Behavior Group

Met 304	Extractive Metallurgy I (4)
Met 305	Extractive Metallurgy II (3)
Met 312	Fundamentals of Corrosion (3)
Chem 381	Radiation and Structure (4)
Chem 382	Structure, Electrochemistry & Kinetics (3)
ChE 392	Introduction to Polymer Science (3)
Chem 397	Colloids and Surface Chemistry (3)
Math	Approved Elective

Typical M.S. Program in Materials

Mechanical Engineering Graduate

Fifth Year, First Semester

Met 333	X-ray Methods (3)
Met 408	Transformations (3)
Met 315	Physical Ceramics (3)
Met 418	Deformation and Fracture (3)
	or
	Approved Technical Elective (3)
	Materials Research (3)

Fifth Year, Second Semester

Met 412	Electric & Magnetic Properties of Materials (3)
Met 343	Physical Polymer Sicence (3)
	Approved Technical Elective (3)
ME 444	Experimental Stress Analysis (3)
	or
	Approved Technical Elective (3)
	Materials Research (3)

Fifth Year, Summer Semester

Materials Research

Course Offerings in Materials

In addition to the courses noted in the list of recommended electives above, a number of other graduate courses concerned with the behavior of materials are taught in the engineering and science departments. Pertinent courses are listed below by department, number and title, and credit hours. Descriptions of these courses may be found in the respective departmental listings in this catalog.

ChE 360	Nuclear Reactor Engineering (4)
ChE 394	Organic Polymer Science (3)
ChE 470	Cryogenic Engineering (3)
ChE 401	Chemical Engineering Thermodynamics (3)
ChE 413	Catalysis (3)
ChE 428	Rheology (3)
ChE 492	Topics in Polymer Science (3)
Chem 443	Solid State Chemistry (3)
Chem 497	Topics in Colloid and Surface Chemistry (3)
CE 459	Advanced Topics in Plastic Theory (3)
Geol 336	Mineral Phase Relations (3)
Geol 435	Advanced Mineralogy (3)
IE 344	Metal Cutting Theory (3)
ME 444	Experimental Stress Analysis in Design (3)
Mech 406	Advanced Vibrations (3)
Mech 409	Theory of Elasticity I (3)
Mech 410	Theory of Elasticity II (3)
Mech 412	Theory of Plasticity (3)
Mech 413	Fracture Mechanics (3)
Mech 415	Stability of Elastic Structures (3)
Met 319	Current Topics in Materials Science (3)
Met 320	Analytical Methods in Materials Science (3)
Met 358	Selection of Materials (3)
Met 406	Solidification (3)
Met 407	Theory of Alloy Phases (3)
Met 408	Transformations (3)
Met 410	The Physical Chemistry of Metals I (3)
Met 412	Electrical & Magnetic Properties of Materials (3)
Met 413	Analysis of Metal Forming Processes (3)
Met 415	Mechanical Behavior of Ceramic Solids (3)
Met 416	Atom Movements (3)
Met 418	Deformation and Fracture (3)
Met 425	Topics in Materials Processing (3)
Met 437	Dislocations and Strength in Crystals (3)
Met 443	Solid State Chemistry (3)
Met 458	Metallurgical Design (3)
Met 461	Advanced Materials Research Techniques (3)
Phys 340	Heat & Thermodynamics (3)
Phys 431	Theory of Solids (3)
Phys 442	Statistical Mechanics
Phys 471	Non-linear Continuum Mechanics (1-3)

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 will, in consultation with the director, select courses in language, history, and other subjects which will give him an intensive knowledge of the culture of the area in which he 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 (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 (3)
	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

Public Administration Option

Acctg 51	Essentials of Accounting (3)
	or
Acctg 108	Fundamentals of Accounting (3)
IR 352	International Organization (3)
	or
IR 361	International Law (3)
Eco 353	Public Finance (3)
Govt 360	Public Administration (3)
Govt 363	Contemporary Political Philosophy (3)
	or
Govt 364	Contemporary Political Analysis (3)
Govt 361	Comparative Administrative Systems (3)
Govt 322	Developing Countries (3)

A senior comprehensive examination in the appropriate language is required.

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.

Major in Business and Economics College

Required: 15 credit hours beyond the core

Eco 303	Economic Development (3)
Eco 309	Comparative Economic Systems (3)
Eco 339	International Trade (3)
Eco 340	International Finance (3)
Eco 305	The Economic Development of Latin America (3)
	or
Eco 343	European Economic Integration (3)

To qualify for this major, include at least one year (beyond the introductory course) of foreign language of your area in the language option as well as one year of history of your area and Government 3 (Comparative Politics) in your social science option.

Fundamental Sciences

Robert T. Gallagher, *Associate Dean of the College of Engineering, Director of Fundamental Sciences Program*

The curriculum in Fundamental Sciences is designed to enable students to achieve a breadth of academic background in the basic 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 flexibility by which a student may prepare for work in industry or government, or approach adequacy for graduate study in a field.

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.

Fundamental science majors are required to concentrate in a major or in a hybrid of two fields. Thus 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.

Work in the major science subjects is continuous through all four years. The freshman year is identical with that required of all students in the College of Engineering. The general studies (GS) requirements of the engineering college must also be satisfied. The discipline of a science 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.

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 field of concentration.

Freshman Year *(See page 45)*

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	Statistical Inference (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)*

*Note: The lower number of credit hours represents the load required to meet the graduation requirement; the higher figure represents the normal semester load.

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.
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 non-professional electives in place of the distribution requirements. Distribution requirements for the B.A. program include at least second-year (intermediate level) proficiency in one foreign language. There is no foreign language requirement in the B.S. 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. Lehigh does not operate its own field camp but arrangements are easily made for Lehigh students to attend field camps operated by other colleges and universities.

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 non-professional 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.

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 (25 credit hours)

Chem 21, 22	Introductory Chemical Principles and Lab (5)
Chem 39	Analytical Chemistry (3)
Chem 90	Physical Chemistry (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 (38 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 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 35)

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, his 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 this 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)
Fundamental concepts of geology; the composition, structure, and development of the earth; processes of geological change. Lectures, laboratory work, and field trip.

10. Computer Applications (1)
The use of computers in the solution of geological problems. Introduction to FORTRAN; the use of published and available programs.

12. Historical Geology (3)
The origin and evolution of the earth and its parts—the continents, ocean basins, hydrosphere, and atmosphere; the origin and evolution of life; regional studies. Lectures, laboratory, and field trips. Prerequisite: Geol. 1.

23. Structural Geology (3)
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.

33. Introductory Mineralogy and Petrology (3)
Principles of crystallography, mineralogy, and petrology; megascopic study, identification, and description of common minerals and rocks. Lectures and laboratory. Prerequisites: Geol. 1, Chem. 21.

101. Geology for Engineering (3)
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.

For Advanced Undergraduates and Graduates

201. Earth Sciences I—Geology (3)
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 chairman of department.

203. Geology Workshop (3)
Field and laboratory exercises in geology. Must be taken concurrently with Geol. 201.

211. Environmental Planning (3)
The systems approach to resource development as it relates to analysis of the need of society. The physical factors of the environment are presented as a framework of reference for evaluation of the developmental alternatives facing individuals and society. Lectures and laboratory.

212. Geomorphology and Surficial Geology (3)
Systematic examination of the surface features of the earth and their interpretation as records of geologic and environmental history. Special emphasis on quantitative methods as applied to geomorphologic investigation, the development and environmental significance of surficial mantles, the physical and sociological effects of Pleistocene glaciation. Lectures and occasional field trips.

281. Geological Research (1-3)
Independent investigation of a special problem in the field, laboratory, or library. Prerequisite: consent of chairman of department.

282. Geological Research (1-3)
Similar to Geol. 281. May be elected as a continuation or separately. Prerequisite: consent of chairman of department.

301. Introduction to Geophysics (3)
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 chairman of department.

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.

311. Paleontology (3)
Morphology of invertebrate fossils, their use in interpreting geologic history; evolution of the faunas and floras. Lectures and laboratory work. Prerequisite: Biol. 21.

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. Weathering and Pedogenesis (3)
An introduction to the study or rock weathering and soil formation. Processes of rock breakdown; alteration of rock materials at the earth's surface; the development of soil horizonation and soil morphology. Prerequisite: consent of department chairman.

317. (Biol. 317) Evolution (3)
For course description see Biology 317.

320. Advanced Computer Applications (1-3)
Independent investigation of special problems utilizing computer techniques. Prerequisite: Geol. 10 or consent of chairman of department.

321. Statistical Applications (3)
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.

322. Geological Sampling (2)
Consideration of elements of sampling theory applicable to geological problems. Geological populations and their variability, sampling techniques and program design, statistical inference. Prerequisite: consent of department chairman or Geol. 321.

333. Crystallography (3)
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.

334. Petrology and Petrography (4)
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.

336. Mineral Phase Relations (3)
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.

337. (Met. 333) X-ray Methods (3)
For description, see Met. 333.

338. (Met. 334) Electron Metallography (3)
For description, see Met. 334.

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 or consent of chairman of department.

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.

357. Economic Geology (3)
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.

363. Introduction to Oceanography (3)
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).

372. Principles of Geochemistry (3)
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. Prerequisite: consent of chairman of department.

381. Meteorology (3)
Principles of meteorology: composition of the atmosphere, physics of the air, weather systems, weather instruments and forecasting. Two lectures, one laboratory.

391. Field Seminar (1)
Study of regional geological problems using field methods of analysis. Field trips. Prerequisite: consent of chairman of department.

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 required 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, Bechman 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 and consent of the instructor.

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.

411. Advanced Paleontology (4)
Classification, evolution, biometrics, and paleoecology; study of fossil and modern populations and assemblages. Lectures and laboratories. Prerequisite: Geol. 311.

417. Sedimentary Petrography (3)
The theory and application of petrographic methods in the study and classification of sedimentary rocks. Prerequisite: Geol. 334.

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.

421. Global Tectonics (3)
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.

422. Regional Tectonics (3)
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 chairman of department.

424. Advanced Structural Geology (3)
The theory and application of analytical methods in the study of rock deformation; experimental deformation, petrofabric analysis; statistical field methods.

435. Advanced Mineralogy (3)
Topics of contemporary interest in mineralogy. Prerequisite: Chem. 302 or equivalent.

436. Advanced Mineralogy (3)
Similar to Geol. 435. Prerequisite: Chem. 302 or equivalent. May be elected separately. Offered as required.

437. Advanced Igneous Petrology (3)
Origin of the diversity of igneous rocks as revealed by field and laboratory studies. Lectures, laboratory, and field trips.

438. Advanced Metamorphic Petrology (3)
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.

454. Genesis of Metalliferous Deposits (3)
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.

461. Marine Geology (3)
Geology of the margins and the floors of the oceans.

462. Paleoecology (3)
Reconstruction of paleoenvironments based on principles of paleoecology and sedimentary petrology. Prerequisites: Geol. 311, 313.

471. High-Pressure Petrology (3)
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 systems. Lectures and laboratories.

472. Solution Geochemistry (3)
The processes of solution, transport, and deposition under hydrothermal conditions. Prerequisite: consent of chairman of department.

480. (Biol. 480) Marine Science Seminar (1)
For description, see Biol. 480.

481. Geological Investigation (1-6)
Research on a special problem field, laboratory, or library study; report required. Credit above three hours granted only when a different problem is undertaken.

482. Geological Investigation (1-6)
Similar to Geol. 481. Credit above three hours granted only when a different problem is undertaken.

483. Thesis (3)
May be elected only by master's degree candidates.

484. Thesis (3)
Continuation of Geol. 483.

490. Special Topics (3)
An extensive study of selected topics not covered in more general courses.

491. Special Topics (3)
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

Frank Thomas Colon, Ph.D.
Leonard I. Ruchelman, Ph.D.

Assistant Professors

Charles N. Brownstein, 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 own education. He 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 interests, concerns and knowledge. The only requirements are that the student majoring in government take one of the two basic courses in the curriculum, Government 1 and Government 3, and that he complete thirty-three (33) semester hours of study in the department, at least fifteen (15) of which must be in advanced courses. As an alternative to the student-designed major program, the department offers a suggested major as a model for a more structured plan from which the student may work.

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 this approach will continue to be presented to the student by the advisor, individual differences and the goal of student responsibility militate against making such a program mandatory.

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 major program. He attempts to help the student relate courses offered by the department to the student's educational goals. He may also 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 to the student.

Completion of the government major is considered suitable training for the undergraduate who wishes to go on to law school, and 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 a suggested major program which serves as a guide to a government major. Such a program would probably meet the needs of most students.

Preliminary Courses

Govt 1	American Political System (3)
Govt 3	Comparative Politics (3)

Advanced Courses

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 302	Comparative State Politics (3)
Govt 306	Public Policy Process (3)
Govt 325	Electoral Process (3)
Govt 351	Constitutional Law (3)
Govt 352	Civil Rights (3)
Govt 353	Law and Politics (3)
Govt 354	Administrative Law (3)
Govt 358	Community and Regional Politics (3)
Govt 359	The Legislative Process (3)
Govt 360	Public Administration (3)

Political Theory—Comparative Politics

Govt 78	Political Behavior (3)
Govt 308	Classical Political Heritage (3)
Govt 316	American Political Ideas (3)
Govt 322	Politics of Developing Nations (3)
Govt 324	Political Systems in Transition (3)
Govt 362	The Soviet Political System (3)
Govt 363	Contemporary Political Philosophy (3)
Govt 364	Contemporary Political Analysis (3)
Govt 365	Political Values of Neo-Freudians and Existentialists (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 for details under Division of Urban Studies, Government Department.

Undergraduate Courses

1. American Political System (3)
Constitutional principles; organization and operation of the national government; the party system, citizenship, and civil rights.

3. Comparative Politics (3)
The political systems of foreign countries; approaches to the study of comparative politics.

74. Political Parties (3)
Organization, function, behavior and effect of parties on the democratic process.

77. Urban Politics (3)
The structure and processes of city government in the United States; city-state and federal-city relationships; the problems of metropolitan areas; political machines and community power structures; the urban politics of municipal reform; city planning and urban renewal.

78. Political Behavior (3)
Behavioral approaches to political science. Application to substantive topics and examples of current research.

103. Modern Political Philosophy (3)
Analysis of schools of political thought, including Contract Theorists, Utilitarians, Idealists, and Marxists.

For Advanced Undergraduates and Graduates

302. Comparative State Politics (3)
Analysis of major questions relating to the role of the states in the American federal systems and their relationship with the national government.

306. Public Policy Process (3)
An analysis of the external and internal influences on the public policy process of formal governmental institutions.

308. Classical Political Heritage (3)
The contribution of significant political theorists from Plato to modern times.

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.

321. Methods for Political Research (3)
Introduction to research, research design (survey, experimental, aggregate), statistical and non-statistical analysis, and computer applications.

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)
Studies of the responses of selected non-communist states to contemporary problems. May be repeated for credit with consent of instructor.

325. Electoral Process (3)
Public opinion, voting behavior, campaigns and elections.

351. Constitutional Law (3)
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 and policy decision-making processes.

352. Civil Rights (3)
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 constitution issues concerning criminal procedure and racial discrimination.

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.

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.

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."

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.

360. Public Administration (3)
The nature of administration; problems of organization and management; public personnel policies; budgeting and budgetary systems; forms of administrative responsibility.

362. The Soviet Political System (3)
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.

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.

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.

366. The Politics of Education (3)
An analysis of the political dimensions of the contemporary crisis in American education. Designed primarily for students in the School of Education. Summer session.

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 chairman of the department.

372. Readings (3)
Continuation of Govt. 371. Prerequisite: consent of chairman of department.

381, 382. Special Topics (3)
A seminar on a topic of special interest in a particular political institution, process, or policy. Prerequisite: consent of chairman of department.

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 (30) hours of approved course work and passing an examination covering the entire field or completing twenty-four (24) 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 will be 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 of government consists of four parts: a core concentration in interpersonal awareness and teaching, a major in government, an open-ended major, and an internship and related project.

The Core Curriculum (12 credit hours)

	Training in Interpersonal Awareness (6)
Govt 471	Teaching Government (3)
Govt 472	Workshop in Teaching Government (3)

Major Area—Government (33 credit hours minimum requirement)

300-level (12 credit hours)

In consultation with his advisor and taking into consideration his past work in government, the student should select courses to achieve a balance in the following general areas: scope and methods; public law and judicial process; subnational politics; public administration; political philosophy; comparative politics or international relations.

400-level (21 credit hours)

The student's courses on the 400-level should focus on American and community politics, the main area of concentration in the Doctor of Arts program. But on this level, too, a balance should be achieved by taking available courses in political philosophy, field research and comparative politics.

Minor Area (12 credit hours)

On the basis of interest and undergraduate education students will be encouraged to select their minor from a wide range of subject areas including both the natural and social sciences. Where possible this will be related to the internship experience of the student. Associated with the department of government will be the departments of social relations, and history, and the division of urban studies.

Internships and Project (33 credit hours)

The student will participate in an evaluated, supervised, part-time teaching internship either at the junior or four-year college level for one semester.

Students will 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 student 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 internship experiences.

Examination

Those students entering the D.A. program without the master's degree in government will be required to take a continuing proficiency examination prior to their second year of study.

The general examination for candidates for the D.A. shall be given not later than the start of their third year and shall consist of (1) examination in their major and minor fields and (2) presentation of their proposed project and internships.

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.

413. Modern Political Philosophy (3)
A study of selected modern political philosophers and their continuing effect on politics and political philosophy.

414. Democratic Theory (3)
A critical evaluation of democratic theory in light of the contemporary challenges to the democratic process.

421. Research Methods (3)
Research approaches, design techniques, statistical and non-statistical analysis, and computer applications.

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.

431. Public Administration (3)
The study of bureaucracy and the problems of public organization and management; executive leadership; personnel, budgeting and regulatory administration.

432. Public Policy Process (3)
Executive, legislative, and judicial interaction in the policy process. External influences upon formal governmental institutions. Presidential advisory system and policy politics, internal congressional process, and judicial policy-making.

441. Judicial Process (3)
An examination of judicial institutions and decision-making process 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.

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.

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.

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.

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 chairman of department.

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.
John Ellis, Ph.D.
Warren Pillsbury, Ph.D.

Assistant Professors

James R. McIntosh, Ph.D.
Roger Simon, Ph.D.

Lecturer

David Amidon, M.A.

Undergraduate Curriculum

This is an interdepartmental program intended for students who wish a broad interdisciplinary focus on urban processes as the means of comprehending multifaceted city problems. The urban studies program 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.

Course schedules are worked out with the advice of the faculty members who actively participate in the urban studies 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 36 credit hours is required.

Required Preliminary Courses (6 credit hours)

US 61	The Study of Urbanization (3)
US 62	Contemporary Urban Issues (3)

At least fifteen (15) credit hours to be chosen from the following:

Eco 1	Economics (4)
Eco 312	Urban Economics (3)
FA 43	Environmental Design (3)
FA 151	History of Urban Design (3)
Govt 77	Urban Politics (3)
Govt 358	Community and Regional Politics (3)
Hist 333	American Urban History to 1880 (3)
Hist 334	American Urban History, 1880 to Present (3)
SR 368	Urban Communities (3)
SR 292	Research Methods (3)
	or
Govt 321	Research Methods (3)

At least fifteen (15) credit hours to be chosen from the following:

Eco 354	Public Finance: State and Local (3)
Eco 337	Transportation and Spatial Economics (3)
FA 143	Environmental Planning and Project (3)
FA 144	Intermediate Environmental Design (3)
FA 152	Physical Planning and Design (3)
Govt 360	Public Administration (3)
Hist 331	The Negro in America (3)
SR 75	Minority Groups (3)
SR 320	Urban Ethnology (3)
US 371, 372	Special Topics (3 each)

Undergraduate Courses

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.

371, 372. Special Topics (3 each)
A seminar on a topic of special interest in urban studies. Prerequisite: consent of the instructor.

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 his chosen department which formally admits him into the program. All students are required to take the urban seminar described below.

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 357	Urban Government (3)
	or
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, advisors: Messrs. Ellis and Simon (30 credit hours)

Hist 401	Methods in Historical Research (3)
Hist 440's	Any course, including 442 when urban topic offered (9)
Hist 450's	Any course, including 452 when urban topic offered (6)

And one course from the following:

SR 468	Advanced Urban Sociology (3)
Govt 321	Methods for Political Research (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 (12)

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)

History

Professors

Lawrence H. Leder, Ph.D., *Chairman*
Raymond Gibson 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 H. Ellis, Ph.D.
George Mark Ellis, Ph.D.
William Gerald Shade, Ph.D.

Adjunct Assistant Professor

Christa V. Graf, Ph.D.

Assistant Professors

John B. Owens, Ph.D.
James S. Saeger, Ph.D.
Roger D. Simon, Ph.D.

Lecturer

Burns V. Machobane, M.Ed.

History is the study of man's activities. As such, it encompasses not only events and public policy, but the whole sweep of cultural achievements—man's religion and philosophy, literature and art, economic and social life. Some of the most influential thinkers and public men 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.

A major in history consists of thirty-six hours distributed in three of four areas: American, British, European, and Latin American history. No more than eighteen of these hours may be in one field. Majors are strongly urged during either their junior or senior years to enroll in History 201; for those interested in the newest statistical approaches to the discipline, History 395 is strongly recommended.

Admission to 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, in addition to the University honors requirements, 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 and elimination of one required preliminary course. Honors students in history must enroll for three hours credit of unrostered history as part of their thirty-six hours and must complete in that course an honors thesis.

Required Preliminary Courses

Hist 1, 2	Course of Civilizations (6)
	or
Hist 51, 52	Freshman Seminar (6)
	Plus one of the following sequences:
Hist 13, 14	American Civilization (6)
Hist 15, 16	English History (6)
Hist 49, 50	History of Latin America (6)

Required Intermediate Courses

Nine hours chosen from the following:

Hist 21	Ancient History (3)
Hist 22	Ancient History (3)
Hist 67	The Iberian Peninsula (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 159	Modern Europe (3)
Hist 160	Modern Europe (3)
Hist 185-186	Archaeological Field Course (8)

Required Major Courses

Fifteen hours chosen from the following:

Hist 201	Historical Perspectives (3)
Hist 321	Social Class and Mobility in American History (3)
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 Present (3)
Hist 339	Human Ecology and Public Health in America (3)
Hist 340	History of American 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 349	The Early Middle Ages (3)
Hist 350	The High Middle Ages (3)
Hist 351	Conservatism in the Modern Age (3)
Hist 355	European Intellectual History (3)
Hist 356	European Intellectual History (3)
Hist 357	The Renaissance and Reformation (3)
Hist 358	Age of the Baroque (3)
Hist 361	A History of Russia to 1855 (3)
Hist 362	A History of Russia, 1855 to Present (3)
Hist 363	Modern Germany, 1648-1848 (3)
Hist 364	Modern Germany, 1848 to Present (3)
Hist 365	Colonial Latin America, 1492-1825 (3)
Hist 366	Modern Latin America, 1825 to Present (3)
Hist 371, 372	Special Topics in History (3 each)
Hist 395	Quantitative Methods in Historical Studies (3)

History majors are encouraged to enroll in courses in economics, English and American literature, government, international relations, philosophy, psychology, religion studies, and social relations. Special notice should be taken of the possibilities of developing programs emphasizing urban studies. 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.

Undergraduate Courses

1. Course of Civilizations (3)
Civilizations in the East, West, and Africa from earliest times to 1700.

2. Course of Civilizations (3)
Civilizations in the East, West, and Africa from 1700 to the present.

13. American Civilization (3)
An integrated survey of political, social, cultural, and economic developments from the founding of Jamestown through Reconstruction.

14. American Civilization (3)
Continuation of History 13; an integrated survey of political, social, cultural and economic developments from Reconstruction to the present.

15. English History (3)
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)
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)
For course description, see Classics.

22. (Latin 22) Ancient History (3)
For course description, see Classics.

49. History of Latin America (3)
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.

50. History of Latin America (3)
Continuation of History 49. The development of the Latin American nations in the nineteenth and twentieth centuries.

51. Freshman Seminar (3)
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)
A continuation of History 51.

67. The Iberian Peninsula (3)
Spain and Portugal from the eighth century to the present, emphasizing the historical influence of Iberian culture on the development of colonial institutions.

119. Colonial America (3)
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.

120. Revolutionary America (3)
American political, economic and cultural development from the mid-eighteenth century through the adoption of the Federal Constitution.

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.

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.

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.

138. United States, 1920 to Present (3)
American institutions in the modern era, emphasizing critical changes of the 1920's, the Crash of 1929, the New Deal, World War II, and later political, social and economic events.

159. Modern Europe (3)
Revolutions and reactions in Western Europe from 1789 to 1870. The rise and spread of liberalism and the origins of Socialism.

160. Modern Europe (3)
Contemporary Europe; the origins and consequences of two World Wars; the rise of revolutionary governments in Italy, Germany, and Russia.

185-186. Archaeological Field Course (8)
This course introduces undergraduate students to a wide range of topics in archaeology. Undergraduates who wish to take this course must file a cross-registration form and apply at Moravian College. Offered only in summer in conjunction with Moravian College.

For Advanced Undergraduates and Graduates

201. Historical Perspectives (3)
Methodologies and interpretations of Western historians from ancient times to the present.

321. (S.R. 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.

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.

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)
Development of political, social, and religious ideas in America from the colonial period to the Civil War.

328. American Intellectual History (3)
Economic, political, and religious thought in industrial America, 1860 to the present.

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)
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."

333. American Urban History to 1880 (3)
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.

334. American Urban History, 1880 to Present (3)
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 city planning profession and idea of "new towns," impact of New Deal and "urban renewal."

339. Human Ecology and Public Health in America (3)
The historical relation between human ecology and public health, emphasizing developments in the nineteenth and twentieth centuries. Readings and research on population growth, infectious disease, use and abuse of drugs, public health administration and environmental control.

340. History of American Medicine (3)
Social history of the theory and practice of medicine, giving particular attention to the scientific and social processes facilitating the rise of physicians as an occupational group, to the social distribution of medical care, and to the role of the patient as consumer.

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.

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.

345. Liberal England (3)
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)
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.

349. The Early Middle Ages (3)
European institutions and cultural developments from 284 A.D. to the mid-eleventh century. Evolution of the Church, feudalism and manorialism, the foundations of the Byzantine, Carolingian, and Holy Roman Empires, and the literary and artistic achievements.

350. The High Middle Ages (3)
A continuation of History 349 to about 1400 A.D. Rise of the universities and towns; legal developments and the origins of representative government; rise of the nation-state; the crusades; Scholasticism and the decline of the medieval church; expansion of trade; and literary and artistic developments.

351. Conservatism in the Modern Age (3)
Conservative political, economic, and social thought from the eighteenth century to the present.

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.

357. The Renaissance and Reformation (3)
The transition from medieval to modern society. Consideration of political, economic, and social forces produced by the Renaissance and their influence upon the dominant religious theme of the Reformation era.

358. Age of the Baroque (3)
Europe from 1648 to 1789. The growth of absolutism in France, the rise of Prussia, and the social and political and economic conditions in the eighteenth century.

361. A History of Russia to 1855 (3)
Major cultural, social, and political traditions of the Russian people.

362. A History of Russia, 1855 to Present (3)
The Great Reforms, collapse of Tsarist absolutism, revolutions of 1917, and formation and consolidation of the Soviet dictatorship.

363. Modern Germany, 1648-1848 (3)
Political, socio-economic, and cultural developments from the age of triumphant absolutism to the failure of liberalism.

364. Modern Germany, 1848 to Present (3)
Political history from the Second Empire to the federal and socialist republics. Twentieth-century intellectual and social problems.

365. Colonial Latin America, 1492-1825 (3)
Individual investigation and reports on selected topics. The Spanish concept of empire, church-state relations, origins of the Wars of Independence.

366. Modern Latin America, 1825 to Present (3)
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.

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 chairman of department.

372. Special Topics in History (3)
Continuation of History 371. Prerequisite: consent of chairman of department.

374. Themes in American History (3)
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.

395. Quantitative Methods in Historical Studies (3)
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.

For Graduates

The Lehigh 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 GRE 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 on three fields chosen from Colonial America, United States since 1789, and Latin American history. Effective with students entering the master of arts program beginning in June 1973, all 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 overall 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)
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.

402. Historiography (3)
A continuation of History 401. The aims, methods, and accomplishments of some of the most renowned historians of Europe and America.

403. Field Work in Archaeology (6)
Application of archaeological methods and techniques in actual site excavation. Archival research, surveying, mapping, excavation, archaeological photography, and artifact processing and analysis will be included, all culminating in an anthropological interpretation of the remains uncovered. Prerequisite: consent of instructor and the chairman of the department. Note: students must put in a full day's work at the site. Offered only in summer in conjunction with Moravian College.

410. Historical Literature: Europe (3)
Designed to familiarize teachers with the important literature in the field. Students will analyze the major interpretations of the most significant movements in modern European history.

420. Historical Literature: America (3)
Designed to familiarize teachers with the important literature in the field. Students will analyze the major interpretations of the most significant movements in American history.

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 chairman of department.

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 chairman of department.

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 chairman of department.

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 chairman of department.

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 chairman of department.

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 chairman of department.

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 chairman of department.

451. Research in Colonial American History (3)
An intensive research seminar on a phase of American colonial 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 chairman of department.

452. Research in United States History (3)
An intensive research seminar on a phase of United States 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 chairman of department.

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 chairman of department.

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 chairman of department.

455. Research in Medieval and Renaissance European History (3)
An intensive research seminar on a phase of Medieval and Renaissance European 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 chairman of department.

456. Research in Early Modern European History (3)
An intensive research seminar on a phase of Early Modern European 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 chairman of department.

457. Research in Modern European History (3)
An intensive research seminar on a phase of Modern European 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 chairman of department.

Industrial Engineering

Professors

Arthur Freeman Gould, M.S., *Chairman*
George Eugene Kane, M.S.
Sutton Monro, B.S.
Wallace James Richardson, M.S.
William Adams Smith, Jr., Ph.D.

Associate Professors

John William Adams, Ph.D.
Gary E. Whitehouse, Ph.D.

Assistant Professors

Mikell Porter Groover, Ph.D.
John D. Landis, Ph.D.
M. Wayne Shiveley, Ph.D.

Instructors

Emory W. Zimmers, Jr., M.S.
David D. Hott, M.S.
Lynne H. Hott, M.S.
Lucius J. Riccio, 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 men, 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 man-power 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 men 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 for industry and business a potential manager, a graduate well grounded in the fundamentals of science, trained in the principles and methods of engineering analysis and design, and adequately prepared to practice the profession of industrial engineering.

Freshman Year (See page 45)

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)

Math 231	Statistical Inference (3)
IE 18	Information Processing Theory (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)
	Electives (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)

Note: The lower number of credit hours represents the load required to meet the graduation requirement; the higher represents the normal semester load. For explanation of Engineering Science Elective, see IE Bulletin.

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. Information Processing Theory (3)
Principles of organizing, sorting and searching data; representation of data in various file media; analysis of work flow manual and equipment functions, types of programming systems; logic representation; validation and control procedures. 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)
Study of metal processing theory with emphasis on machining, numerical control, special processing techniques, workholder design, laboratory experiments.

102. Work Systems (3)
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.

154. Senior Project (3)
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)
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)
A course for the engineering student not majoring in I.E. 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)
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: Math. 231, or equivalent.

206. Operation Research Techniques (4)
The development and use of the techniques of operations research. Topics include linear programming, queueing theory, dynamic programming, probabilistic inventory models, and simulation. Prerequisites: 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 instructor.

300. Apprentice Teaching in I.E. ——— (1-3)

307. Information Systems Engineering (3)
Information systems design methods. Graphical and matrix techniques. Boolean logic. Information network models and feedback concepts in dynamic information systems. Prerequisites: Math. 205, 231.

309. Data Processing Systems (3)
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)
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.

311. Decision Processes (3)
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 chairman of department.

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)
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 chairman of department.

334. Organizational Planning and Control (3)
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)
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 the chairman of department.

336. Analysis of Experimental Data (3)
Design of simultaneous experiments including randomization, blocking, analysis of variance with equal cell frequencies and general regression. Prerequisite: I.E. 205 or consent of chairman of department.

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.

344. Metal Cutting Theory (3)
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 his area of interest; (2) prepare himself, through formal course work and independent study, for examination in his particular area of specialization by members of the graduate faculty; and (3) present a dissertation related to his 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 of industrial engineering entitled, "The Ph.D. Program in Industrial Engineering."

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. 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 are a modern metal processing research laboratory and a SCI 5800 (Computer Systems, Inc.) Analog Computer with over one hundred operational amplifiers. 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 instructor.

410. Design of Experiments (3)
Fixed, mixed, and random models, fractional factorials, unequal cell frequencies. Sequential design for estimation and optimization. Prerequisite: consent of chairman of department.

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)
Random number generation and testing; design of simulation experiments for the reduction of variance of estimators; simulation languages; application of simulation to industrial problems.

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: Math. 309 or I.E. 429 or equivalent.

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: Math. 309 or I.E. 429 or equivalent.

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)
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 paraments 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

Carey Bonthron Joynt, Ph.D., *Chairman*
Henderson Bampfield Braddick, Ph.D.
Aurie Nichols Dunlap, Ph.D.
Oles M. Smolansky, Ph.D.

Associate Professor

Zdenek J. Slouka, Ph.D.

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 young 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.

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 Courses

IR 1, 2	World Politics (6)

Required Major Courses

IR 341, 342	International Relations (6)
IR 351, 352	International Institutions (6)
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)
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.

2. World Politics (3)
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.

11. European International Relations, 1815-1919 (3)
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.

12. European International Relations Since 1919 (3)
The political and strategic structure of Europe in the 1920's; 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.

21. The Diplomacy of the Far East to 1919 (3)
The opening of China and Japan; the modernization of Japan; China's failure to modernize; the division of China into spheres of influence; international rivalries in Korea, Manchuria, and Southeast Asia; economic and territorial imperialism.

22. The Diplomacy of the Far East Since 1919 (3)
An analysis of recent and contemporary political and economic problems confronting not only the countries of the Orient but the other powers with interests in that region; Japan's attempt to establish a New Order in Greater East Asia; the defeat and recovery of Japan; the ascendancy of communism in China and its consequences.

31. The Middle East in World Affairs (3)
An analysis of the political, economic and social forces which have led to the rise of the modern states in the Middle East. Emphasis will be placed upon the role of the area in international politics from the invasion of Egypt by Napoleon to 1918.

32. The Middle East in World Affairs (3)
The mandates system and the Palestine problem; movements of modernization in Turkey and Iran; the rise of Arab nationalism; the impact of the Second World War upon the position of Britain and France; the growth in influence of the United States and the Soviet Union; the emergence of Israel and its impact on the Arab states; the rise of Nasserism and the Suez Crisis; the growth of neutralism.

133. The Diplomacy of Russia to 1917 (3)
Development and expansion of the Russian Empire; principles of Russian foreign policy and their specific applications under the Tsarist and Provisional Governments, treated partially as backgrounds of Soviet policy; interaction between Russian domestic and foreign affairs.

134. The Diplomacy of Russia Since 1917 (3)
A topical and chronological survey of Russian foreign relations in the Soviet period; philosophical, psychological, economic, social, and other factors influencing the formulation and execution of foreign policy; interaction between Soviet domestic and foreign affairs.

For Advanced Undergraduates and Graduates

300. Apprentice Teaching in I.R. ——— (3)

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 1930's; the Second World War. Prerequisite: consent of instructor.

312. World Affairs Since 1945 (3)
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 instructor.

313. (Rel. 313) Religion and International Affairs (3)
Theological assessments of the nation-state, the role of power in international affairs, national sovereignty and internationalism, and war, pacificism, and alternative methods of conflict-resolution.

323. Southeast Asia in World Affairs (3)
Analysis of the period since the beginning of the Second World War with special attention to the effect of the Japanese conquest of the area, the rise of independent states, the development of the foreign policies of the new states, Great Power influence, and the development of the Vietnam conflict. Prerequisite: consent of chairman of department.

324. The Far East in World Affairs (3)
Analysis of the period since the Second World War with special attention to the foreign policy of Communist China, the foreign policy of Japan since the peace treaty and the role of the Great Powers in the various postwar crises in the area. Prerequisite: consent of chairman of department.

334. The Soviet Union in World Affairs (3)
An appraisal of the objectives 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 chairman of department.

341. International Relations (3)
An examination of contemporary theories and basic concepts of world politics, with application to historic and current issues of international politics. Consent of chairman of department.

342. International Relations (3)
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 chairman of department.

351. International Institutions (3)
Theory and functioning of the League of Nations and the United Nations with particular reference to the problems of collective security, enforcement, and the pacific settlement of disputes; functional and regional organizations; diplomacy by conference; state sovereignty and inter-state organization.

352. International Institutions (3)
Continuation of I.R. 351, with emphasis upon the United Nations.

361. International Law (3)
General theories of law and their application to international law; international lawmaking, adjudication and enforcement; personality of states, international organizations, corporations and persons; state succession; title to territory; jurisdiction over territory, waters, airspace, outer space and persons; the state and the foreign corporation.

362. International Law (3)
Privileges and immunities of diplomatic and consular officers and of international organizations; treaties and agreements; pacific settlement; measures short of war; collective security; the legal status of war and the laws of war; war crimes trials and international criminal jurisdiction.

371. Readings in International Relations (3)
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 chairman of department.

372. Readings in International Relations (3)
Continuation of I.R. 371. May be repeated for credit. Prerequisite: consent of chairman of department.

381. Special Topics (3)
An intensive study of some aspects of international politics not covered in another course. Prerequisite: consent of chairman of department.

382. Special Topics (3)
A continuation of I.R. 381. Prerequisite: consent of chairman of department.

391. The Teaching of International Relations (3)
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.

For Graduates

Between twelve and fifteen students currently are pursuing the master of arts degree in the department of international relations. The Ph.D. is not offered.

Each student's program is planned on an individual basis to take advantage of his previous academic work and his career goals.

A thorough understanding is required of basic theoretical issues and, unless the student comes prepared, he will be expected to undertake a course in theoretical analysis. Emphasis throughout the department is upon the fundamentals of international politics as they affect international law and institutions and the policies and activities of the Great Powers.

The department offers advanced work in theories of international politics and special work in Soviet affairs, Middle Eastern politics, European international relations between the wars, international law and military problems as well as arms control and disarmament studies. The department feels this is attractive preparation for a student who wishes to continue work toward the doctorate, as a great many departmental majors have done at leading institutions in this country and abroad.

Candidates for the master's degree may qualify either by completing successfully thirty hours of approved course work and passing an examination covering the entire field or by completing twenty-four hours in approved courses and submitting a satisfactory thesis. Each candidate will select the plan better suited to his needs and abilities, upon the advice and with the approval of the chairman of the department, and will be required to take a comprehensive oral examination. In addition, each candidate is normally expected to possess an adequate reading knowledge of one modern foreign language.

Students will be encouraged to include in their programs appropriate courses in economics, government, history, psychology, and social relations.

441. Seminar in International Relations (3)
Intensive analysis of selected forces and problems of world politics.

442. Seminar in International Relations (3)
Continuation of I.R. 441.

451. Seminar in International Organization (3)
Intensive analysis of selected agencies and activities of the League of Nations and affiliated institutions.

452. Seminar in International Organization (3)
Continuation of I.R. 451, with emphasis upon the United Nations.

461. Seminar in International Law (3)
Intensive analysis of the principal theories concerning the nature of international law and its fundamental conceptions, with special studies of their application and significance in contemporary international society.

462. Seminar in International Law (3)
Continuation of I.R. 461.

471. Special Topics (3)
Selected topics in the field of international politics not covered in other courses. May be repeated for credit. Prerequisite: consent of chairman of department.

472. Special Topics (3)
Continuation of I.R. 471. May be repeated for credit. Prerequisite: consent of chairman of department.

Management & 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.

Associate Professors

Carl R. Beidleman, Ph.D.
John W. Bonge, Ph.D.
Leon Elwood Krouse, Ph.D.
Benjamin Litt, Ph.D.
Max Donald Snider, M.B.A., *Assistant Dean of the College of Business and Economics*
Gary E. Whitehouse, Ph.D.

Assistant Professors

Bruce M. Smackey, Ph.D.
Charles F. Vihon, D.J.

Adjunct Professors

Harry A. Dower, LL.B.
Edward H. McGee, LL.B.

Instructors

James A. Greenleaf, M.A.
Jay C. Lacke, M.B.A.
Edward W. Schmitt, M.B.A.

Finance

Major in Arts and Science College

Required Preliminary Courses

Eco 1	Economics (4)
Math 41	BMSS Calculus I (3)
Math 42	BMSS Probability (3)
Math 43	BMSS Linear Algebra (3)
Fin 225	Business Finance (3)
Eco 129	Money and Banking (3)
Eco 45	Statistical Method (3)
Acctg 108	Fundamentals of Accounting (3)

Required: 15 credits beyond the core listed on page 35, 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)

Major in Business and Economics College

Required: 15 credits beyond the core listed on page 40, from the following:

Fin 323	Investments (3)
Fin 324	Security Analysis (3)
Fin 326	Problems in Financial Mangement (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

225. Business Finance (3)
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. 3 and Acctg. 51 or Acctg. 108.

300. Apprentice Teaching in Fin. ——— (1-3)

323. Investments (3)
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: a course in corporation finance.

324. Security Analysis (3)
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.

326. Problems in Financial Management (3)
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)
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)
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.

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: preparation in finance acceptable to the department chairman.

372. Special Topics (1-3)
Special problems and issues in finance 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 finance acceptable to the department chairman. May be repeated.

For Graduates

415. (Eco. 415) Capital and Interest Theory (3)
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 the instructor.

421. Financial Management (3)
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)
This course is designed to integrate the theoretical and empirical aspects of the economic environment with the investment analysis associated with portfolio management program of financial intermediaries and individuals. Particular emphasis will be given in the course to the current impingements of the economic environment upon portfolio management decisions. Prerequisite: a course in investments.

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)
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 instructor.

471. Directed Readings (1-3)
Graduate readings in finance not covered in regularly scheduled coursework. Prerequisite: preparation in finance acceptable to the 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 will vary according to interests in finance acceptable to the department chairman. May be repeated.

Law

Undergraduate Courses

101. Business Law (3)
The law of contracts, sales and bailments; legal method and the judicial process.

102. Business Law (3)
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)
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)

320. Social Change and the Law (3)
Examination of how law and the legal process accommodate society's pressures for change within existing institutional frameworks. Representative topics include fair employment practices, open housing, consumer credit and protection, and private and public access to information. Prerequisite: Law 101 or Law 211.

For Graduates

401. Legal Problems in Business (3)
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.

410. Law and Urban Society (3)
Exploration of the juridical aspects of and conditions for institutionalized decision-making in urbanized society. Topics include the relationship between public and private decision-making and the distribution of legal power between levels of government. Prerequisite: Law 101 or Law 211.

Management

Major in Business and Economics

Required: 15 credits beyond the core listed on page 40 from the following:

Required Courses

Mgt 301	Business Management Policies (3)
Mgt 302	Quantitative Models—Conceptual (3)

Elective Courses

Three courses (9 credit hours) may be selected from the following, with no more than six credits taken from outside the College of Business and Economics.

Mgt 304	Quantitative Models—Applications (3)
Mgt 321	Organization Behavior (3)
Mgt 331	Industrial Relations (3)

Mgt 371	Directed Readings (1-3)
Mgt 372	Special Topics (1-3)
Acctg 311	Accounting Information System (3)
Eco 335	Manpower Economics (3)
Eco 338	Labor Market Institutions (3)
Eco 352	Advanced Statistical Methods (3)
Govt 360	Public Administration (3)
IE 333	Organization and Administration (3)
Psych 121	Encountering Self and Others (3)
Psych 201	Industrial Psychology (3)
Psych 251	Psychological Perspectives in Technological Society (3)
SR 303	Group and Organization (3)
SR 304	Human Communication (3)
SR 383	Industrial Sociology (3)

Undergraduate Courses

300. Apprentice Teaching in Mgt. ——— (1-3)

301. Business Management Policies (3)
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 goals' 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 management or marketing major, or senior standing in College of Business and Economics with consent of department chairman.

302. Quantitative Models—Conceptual (3)
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.

304. Quantitative Models—Applications (3)
Extension and application of selected topics covered in Mgt. 302. Development of term projects to solve practical problems. Prerequisite: Mgt. 302.

321. Organization Behavior (3)
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. 201 (or a course in psychology) and permission of the department head.

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: preparation in management acceptable to the 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: preparation in management acceptable to the department chairman. May be repeated.

412. Organization Structures and Processes (3)
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. Prerequisite: Mgt. 201 or a contingency course in psychology and permission of the instructor.

417. (I.E. 417) Advanced Mathematical Programming (3)
For description, see I.E. 417.

418. Analytical Methods in Management (3)
Application of management science methods to industrial and commercial problems. Scientific method, decision theory, linear programming, inventory control, regression analysis, forecasting, simulation, and related areas are examined in the context of accounting, finance, marketing and manufacturing. Prerequisite: Mgt. 302 or consent of instructor.

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 in corporating 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)
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 student should take the course in the last semester of his MBA program.

471. Directed Readings (1-3)
Graduate readings in management not covered in regularly scheduled coursework. Prerequisite: preparation in management acceptable to the 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: preparation in management acceptable to the department chairman. May be repeated.

Marketing

Major in Business and Economics College

Required: 15 credits beyond the core listed on page 40 from the following:

Required Courses

Mgt 301	Business Management Policies (3)
Mgt 302	Quantitative Models—Conceptual (3)
Mkt 312	Marketing Research (3)

Elective Courses

Two courses (6 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)

Undergraduate Courses

211. The American Marketing System (3)
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)
The purposes and effects of marketing communications including the formation, performance, and dissolution of channels of communications, and socioeconomic aspects. Prerequisite: Mkt. 211.

For Advanced Undergraduates and Graduates

220. Behavioral Aspects of Selling (3)
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 instructor.

300. Apprentice Teaching in Mkt. ——— (1-3)

312. Marketing Research (3)
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)
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 equivalent.

317. Industrial Marketing (3)
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.

319. New Product Planning (3)
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 head.

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: preparation in marketing acceptable to the 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: preparation in marketing acceptable to the 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.

450. Marketing Planning and Organization (3)
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.

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: preparation in marketing acceptable to the 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: preparation in marketing acceptable to the 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.
Gilbert Allan Stengle, Ph.D.
Albert Wilansky, Ph.D.

Associate Professors

Samuel Linial Gulden, M.A.
Gregory T. McAllister, Ph.D.
George E. McCluskey, Ph.D.
Gerhard Rayna, Ph.D.
Murray Schechter, Ph.D.
Andrew Kagey Snyder, Ph.D.
David Trutt, Ph.D.

Assistant Professors

Franklin S. Brenneman, Ph.D.
Paul L. Davis, Ph.D.
Bennett Eisenberg, Ph.D.
Gary Bernard Laison, Ph.D.
Robert W. Johnson, Ph.D.
Viswanatha Raja Gopala Rao, Ph.D.
Ruth Silverman, Ph.D.
Herbert Bancroft Skerry, Ph.D.

Lecturers

Marguerite B. Gravez, M.A.
Gail Chadwell Herz, Ph.D.

The major in mathematics is designed to cover each of the three main divisions of mathematics: Analysis, Geometry, and Algebra. Rigor and abstraction, properly motivated, are introduced early in the major in the firm belief that therein lies the essence of mathematics, not only as a liberal discipline studied for its own sake, but also in the deeper applications of mathematics to the sciences. On completion of the major program, it is expected that the student will have gained an appreciation of the universal character of the subject as well as the ability to think in mathematical terms. With this broad orientation, he could readily become a

teacher with a penetrating knowledge of his field, a skilled user of mathematics in one of the rapidly multiplying positions in industry and government, or a student in graduate school, continuing to advance to the frontiers of study and research in mathematics.

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
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)
	Approved Electives (12)

Note: The elective courses must include Math. 307 or Math. 320. Both may be selected. Students with a special interest, such as applied mathematics, may include mathematically-oriented 200- or 300-level courses offered by other departments. Approval by a designated representative of the chairman of the department is required.

Students interested in actuarial science can major in mathematics, choosing appropriate courses in consultation with a representative of the chairman of the department, to prepare for certain of the actuarial examinations.

Undergraduate Courses

21. Analytic Geometry and Calculus I (4)
Functions and graphs; limits and continuity; derivative and differential; indefinite and definite integral; logarithm and exponential.

22. Analytic Geometry and Calculus II (4)
Trigonometric and hyperbolic functions; integration; vector algebra and calculus; solid analytic geometry. Prerequisite: Math. 21.

23. Analytic Geometry and Calculus III (4)
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)
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)
Vector calculus; solid analytic geometry; 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)
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)
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)
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)
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 and 43, or 21 and 43, or consent of chairman of the department.

81. Computers and Calculus (1)
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)
A continuation of Math. 81. Prerequisite: Math. 81 or consent of chairman of department.

105. Computer Programming (3)
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.

110. (I.S. 110) Algorithmic Reasoning (3)
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.

171. Reading Courses in Mathematics (1)
Credit not to exceed one hour per semester, total credit not to exceed three hours; approval of program and written report required. Prerequisite: consent of chairman of department.

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.

205. Linear Methods (3)
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)
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)
The real number system; limits; continuous functions; differentiation; integration; infinite series. Prerequisite: Math. 23, Math. 32 or nine semester hours of differential and integral calculus.

220. Principles of Analysis II (3)
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)
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)
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.

231. Statistical Inference (3)
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)
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)
A continuation of Math. 243. Prerequisite: Math. 243.

251. Mathematical Methods (1-4)
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 instructor. With consent of the department chairman, may be repeated for credit. Offered occasional years.

252. Mathematical Methods (1-4)
A survey of topics in analysis for graduate students in fields other than mathematics, either continuing topics treated in Math. 251 or introducing new topics. Prerequisites: graduate standing and consent of the instructor. With consent of the department chairman, may be repeated for credit.

284. Number Theory (3)
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 the chairman of the department.

285. Introduction to Geometries (3)
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)
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)
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.

304. Axiomatic Set Theory (3)
A development of set theory from axioms; relations and functions; ordinal and cardinal arithmetic; recursion theorem; axiom of choice; independence questions. Prerequisite: Math. 219 or consent of the instructor.

307. General Topology I (3)
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)
Polyhedra, fundamental groups, simplicial and singular homology. Prerequisites: Math. 307 and Math. 327.

309. Theory of Probability (3)
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.

310. Probability and its Applications (3)
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 the chairman of the department.

317. (E.E. 317, I.E. 317) Analytical Methods for Information Sciences (3)
For description, see E.E. 317.

320. Ordinary Differential Equations (3)
The analytical and geometric theory of ordinary differential equations, including such topics as linear systems, systems in the complex plane, oscillation theory, stability theory, geometric theory of non-linear systems, finite difference methods, general dynamical systems. Prerequisite: Math. 220 previously or concurrently and Math. 205.

322. Methods of Applied Analysis I (3)
Fourier series, eigenfunction expansions, Sturm Liouville problems, Fourier integrals and their application to partial differential equations; special functions. Emphasis is on a wide variety of formal applications rather than logical development. Prerequisite: Math. 205 or consent of chairman of department.

323. Methods of Applied Analysis II (3)
Green's functions; integral equations; variational methods; asymptotic expansions, method of saddle points; calculus of vector fields, exterior differential calculus. Prerequisite: Math. 322.

327. Groups and Rings (3)
An intensive study of the concepts of group theory including the Sylow theorems, and of ring theory including unique factorization domains and polynomial rings.

331. Numerical Analysis (3)
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)
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 the chairman of the department.

334. Mathematical Statistics (3)
Populations and random sampling; sampling distributions; theory of statistical estimation; criteria and methods of point and interval estimation; theory of testing statistical hypothesis; analysis of variance; non-parametric methods. Prerequisite: Math. 309 or consent of the chairman of the department.

350. Special Topics (3)
A course covering special topics not sufficiently covered in the general courses. Prerequisite: consent of the chairman of department. May be repeated for credit. Offered occasional years.

361. (I.S. 361) Theory of Formal Grammars (3)
For description see I.S. 361.

362. Computer Languages (3)
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 the instructor.

371. Readings in Mathematics (3)
The study of a topic in mathematics under appropriate supervision; designed for the individual student who has studied extensively and whose interests lie in areas not covered in the listed courses. Prerequisite: consent of the 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 1972 there were about fifty-five 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 terminal 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. His 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.

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.) He must also 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 separate announcement available from the department.

401. Real Analysis I (3)
Spaces of continuous functions; the Lebesgue integral; differentiation; general theory of measure and integration; Banach and Hilbert spaces; L^p-spaces. Applications to such topics in classical analysis as integral equations and Fourier series. Prerequisite: Math. 307 or consent of the chairman of the department.

402. Real Analysis II (3)
Continuation of Math. 401. Prerequisite: Math. 401.

404. Mathematical Logic (3)
Advanced topics in quantification theory relevant to formalized theories, recursive functions, Godel's incompleteness theorem; algorithms and computability. Prerequisite: Math. 303.

405. Partial Differential Equations (3)
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)
Continuation of Math. 405. Prerequisite: Math. 405.

407. Transforms (3)
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.

408. Boundary Value Problems (3)
The study of boundary value problems with attention to integral equations, special functions, variational methods, and eigenvalue problems. Prerequisites: Math. 220 and either Math. 208, Math. 226, or Math. 415.

409. Mathematics Seminar (3 or 6)
An intensive study of some field of mathematics not offered in another course. Prerequisite: consent of chairman of department.

410. Mathematics Seminar (3 or 6)
Continuation of the field of study in Math. 409 or the intensive study of a different field. Prerequisite: consent of chairman of department.

415. Complex Function Theory (3)
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 of the department.

416. Complex Function Theory (3)
Continuation of Math. 415. Prerequisite: Math. 415 or consent of the chairman of the department.

419. Linear Operators in Hilbert Space (3)
Algebra and calculus of bounded and unbounded operators in Hilbert space, with applications to differential operators and integral equations. Spectral analysis of self-adjoint, normal, and unitary operators. Emphasis will be given to those aspects of the theory which have applications in the physical sciences. Prerequisite: Math. 208, Math. 226 or Math. 415.

423. Differential Geometry I (3)
The differential geometry of curves and surfaces in Euclidean space, including problems in the large.

424. Differential Geometry II (3)
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.

425. Differential Geometry III (3)
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.

428. Fields and Modules (3)
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.

435. Functional Analysis I (3)
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.

436. Functional Analysis II (3)
Continuation of Math. 435. Prerequisite: Math. 435.

443. General Topology II (3)
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)
Continuation of Math. 308. Cohomology theory, products, duality. Prerequisite: Math. 308.

445. Algebraic Topology III (3)
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 chairman of department.

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.

457. Summability (3)
The summability of sequences, series, and functions including the development of one or more of the following topics: the classical theorems of Toeplitz, Schur, and Kojima; summability of Fourier and Taylor series; inclusion, equivalence and consistency theorems; functional analytic methods in summability; summability in more general settings such as linear spaces or topological groups. With permission may be repeated for credit. Prerequisite: consent of the chairman of the department.

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.

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, potential theory. Prerequisites: Math. 310 and Math. 401.

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)
A survey of our knowledge of the solar system.

2. Stellar Astronomy (3)
Survey of our knowledge of stars and stellar systems.

211. Stellar Structure and Evolution (3)
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)
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)
Relativistic plasmas, x-ray sources, quasars, pulsars, radio galaxies, origin and evolution of galaxies, current research. Prerequisites: Math. 23 or 32, previously or concurrently, and Phys. 21.

242. Relativity and Cosmology (3)
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 & Mechanics

Professors

Ferdinand Pierre Beer, Ph.D., *Chairman*
Russell Edward Benner, Ph.D.
Philip Anthony Blythe, Ph.D.
Forbes Taylor Brown, Ph.D.
John C. Chen, Ph.D.
James Vandeusen Eppes, M.S.
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.
Alan Hugh Stenning, Sc.D.
Eric Varley, Ph.D.
Robert Peh-Ying Wei, Ph.D.

Associate Professors

Andrew D. Dimarogonas, Ph.D.
Ronald John Hartranft, Ph.D.
Edward Kenneth Levy, Ph.D.
Robert Alan Lucas, Ph.D.
Alistair 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.
Gopal D. Gupta, Ph.D.
Peter D. Hilton, Ph.D.
Mustafa R. Ozgu, Ph.D.
James Peter Ries, Ph.D.

Instructor

Marlin E. Kipp, M.S.

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 B.S. in Mechanical Engineering or the B.S. 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 B.S. in Mechanical Engineering take an additional course in thermodynamics and are required to take at least two professional M.E. courses during their senior year. They should use the technical electives to develop competence in design, thermofluid sciences, 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 45)

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)
CE 11	Engineering Graphics (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 (3)
	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	Statistical Inference (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	Electrical Circuits & Apparatus (3)
EE 161, 162	Electrical Problems & Lab (2)
	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)

Note: In their junior year, candidates for the B.S. in M.E. will take M.E. 105; candidates for the B.S. in Engineering Mechanics will 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 B.S. in M.E., 6 hours of approved electives shall be in M.E. and at least 6 more in M.E. or mechanics. For candidates for the B.S. in Engineering Mechanics, the following courses shall be required: Mech. 302, Advanced Dynamics; Mech. 305, Advanced Mechanics of Materials; Mech. 307, Mechanics of Continua; and Math. 322, Methods of Applied Analysis I.

The lower number of credit hours in the senior year represents the load required to meet the graduation requirement; the higher represents the normal semester load.

Mechanical Engineering

Undergraduate Courses

100. Industrial Employment (0)
Usually following the junior year, students in the mechanical engineering 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)
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)
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 is 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)
Basic concepts and principles of thermodynamics with emphasis on universal applications. First and Second Law development. Energy equations. Reversibility and irreversibility. Entropy and probability. Thermodynamic functions. Properties of pure substances. Prerequisites: Math. 23, Phys. 3 or 11.

105. Thermodynamics II (3)
Thermodynamics applications. Reversible and irreversible processes and cycles with various fluids. Gas and vapor mixtures. Compressible and incompressible fluid flow. Prerequisite: M.E. 104.

108. Laboratory I (2)
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)
Continuation of M.E. 108 with emphasis on project investigations.

110. Thesis (1-3)
Candidates for the degree of B.S. in M.E. may, with the approval of the director of the curriculum, undertake a thesis as a portion of the work during the senior year.

161. Mechanical Engineering Laboratory (1)
Testing of mechanical engineering equipment. Prerequisite: M.E. 104.

166. Procedures for Mechanical Design (2)
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.

168. Elements of Mechanical Design (2)
Elements of mechanical design: motion and force analysis, sizing of members, selection of materials for failure prevention, production requirements. Selected examples of system design. Prerequisite: Mech. 11.

211. Mechanical Engineering Analysis (3)
Engineering analysis methodology. Basic analog computer theory and programming. Numerical methods for use with the digital computer. Performance prediction of selected mechanical engineering systems using analog and digital computer methods. Prerequisite: M.E. 242.

For Advanced Undergraduates and Graduates

220. Thermodynamics (3)
Principles of classical thermodynamics with applications to engineering problems. Introduction to statistical thermodynamics. Prerequisites: Phys. 3 or 11; Math 23.

231. Fluid Mechanics (3)
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)
Physical modeling of vibrating systems. Free and forced single degree of freedom systems. Matrix formulation and solution of multi-degree of freedom systems. Simple continuous and non-linear systems. Engineering applications. Prerequisites: Mech. 102 or 103, Math. 205.

310. Projects (1-6)
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 chairman of department.

312. Synthesis of Mechanisms (3)
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. Prerequisite: Math. 205, Mech. 102.

320. Thermodynamics III (3)
Kinetic theory of gases, statistical thermodynamics. Advanced and specialized topics in thermodynamics. Prerequisite: M.E. 104.

321. Introduction to Heat Transfer (3)
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.

322. Gas Dynamics (3)
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.

324. Aerospace Propulsion Systems (3)
Cycle analysis of air-breathing engines. Optimum configurations for different flight regimes. Chemical and nuclear rocket engines. Electrical propulsion devices. Rankine and Brayton cycles for space power plants. Component design. Prerequisite: M.E. 105.

325. Vehicular Propulsion Systems (3)
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.

331. Fluid Mechanics (3)
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.

340. Advanced Mechanical Engineering Design (3)
Optimum design of mechanical components and systems. Parameter optimization methods including the theory of maxima and minima, geometric programming and optimum seeking methods. Computer-aided and automated design. Computer programming of design theory, life function of components and design for reliability. Prerequisite: Math. 231.

341. Mechanical Systems (3)
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 integration of associated analytical methods into rational design procedures. Prerequisites: Mech. 203 and M.E. 242.

343. Control Systems (3)
Linear analysis of mechanical, hydraulic, pneumatic, thermal and electrical feedback control systems. Transient and frequency response, root locus, stability criteria and compensation techniques. Prerequisite: Math. 205, M.E. 242.

350. Special Topics (1-3)
A study of some field of mechanical engineering not covered in the general courses. Prerequisite: consent of the chairman of department.

360. (Ch.E. 360) Nuclear Reactor Engineering
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.

For Graduates

In the thermal-fluid 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 underway. 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 analytical and experimental work is being carried out on heat pipes, and studies of boiling and two phase flow are in progress. A specially designed closed jet water tunnel is available for research on internal flows. A six inch interferometer can be used for studies in heat transfer and fluid mechanics.

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 underway 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 permit 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 his formal course work the student will register for 6 hours of M.E. 460, design project, and submit an acceptable design project as his 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 his graduate program. He 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 chairman of the department during his first year and arrange for the qualifying examinations.

420. Advanced Thermodynamics (3)
Critical review of first and second laws, entropy, and general thermodynamic equations and relations; applications to current problems in technology and research.

421. Topics in Thermodynamics (3)
Emphasis on theoretical and experimental treatment of combustion processes including dissociation, flame temperature calculations, diffusion flames, stabililty 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)
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.

426. Radiative and Conductive Heat Transfer (3)
Principles of radiative transfer; thermal-radiative properties of diffuse and specular surfaces; radiative exchange between bodies; radiative transport through absorbing, emitting and scattering media. Advanced topics in steady-state and transient conduction; analytical and numerical solutions; problems of combined conductive and radiative heat transfer. Prerequisite: M.E. 321 or Ch.E. 421.

427. (Ch.E. 427) Multiphase Heat Transfer (3)
Heat transfer and fluid dynamics of multiphase systems. Subcooled, nucleate, and film boiling; bubble nucleation; dynamics of bubble growth and collapse; vapor-liquid cocurrent flow regimes; two-phase pressure drop and momentum exchange, low instabilities; convective-flow boiling; simultaneous heat and mass transfer. Prerequisite: M.E. 321 or Ch.E. 421.

428. Boundary Layers and Convective Heat Transfer (3)
Navier-Stokes and energy equations, laminar boundary layer theory, analysis of friction dray, 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. Prerequisites: M.E. 331 or M.E. 321.

431. Advanced Gas Dynamics (3)
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.

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. Prerequisites: M.E. 320, M.E. 322.

439. Fluid Mechanics of Turbo-machinery (3)
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.

442. Analytical Methods in Engineering I (3)
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.

443. Analytical Methods in Engineering II (3)
Continuation of M.E. 442.

444. Experimental Stress Analysis in Design (3)
Applications of experimental stress analysis to mechanical design problems.

446. Reliability Engineering (3)
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.

449. Systems Analysis and Optimization (3)
Methods for the analysis and optimization of mechanical engineering systems. General theory of linear multivariable dynamic systems, state variable method of solution. Variational methods of optimization. Applications to electromechanical, machine and control systems design.

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.

457. (E.E. 457) Introduction to Modern Control Theory (3)
State-space analysis in the time and frequency domains. Observability, controllability, stability. Feedback, feed-forward, and compensation techniques of control. Quadratic performance indices and system optimization; Pontryagin's maximum principle. Prerequisite: M.E. 343, or E.E. 212, or Ch.E. 386.

458. Modeling of Dynamic Systems
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. 343, or E.E. 212; Mech. 302.

459. Advanced Topics in Control
Analytic, graphical and numerical methods in nonlinear control systems, plus one or more of the following: distributed parameter systems; optimal and self-optimalizing control; stochastic signals and systems; dynamic programming; applications to a class of engineering devices. Prerequisite: M.E. 449 or Ch.E. 442.

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 is carried out as needed to promote design development. Prototypes are constructed and tested, when practical.

Mechanics

Undergraduate Courses

1. Statics (3)
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)
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)
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)
Kinematics and kinetics of particles and rigid bodies; relative motion; dynamic equilibrium; work and energy; impulse and momentum. Prerequisites: Mech. 1; Math. 23.

103. Principles of Mechanics (4)
Composition and resolution of forces; equivalent force systems; equilibrium of particles and rigid bodies; friction. Kinematics and kinetics of particles and rigid bodies; relative motion; work and energy; impulse and momentum. Prerequisites: Math. 23 and Phys. 11.

For Advanced Undergraduates and Graduates

203. Advanced Strength of Materials (3)
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)
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.

305. Advanced Mechanics of Materials (3)
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.

307. Mechanics of Continua (3)
Fundamental principles of the mechanics of deformable bodies. Study of stress, velocity and acceleration fields. Compatability 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.

313. Fracture Mechanics (3)
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.

323. (C.E. 324) Fluid Mechanics of the Ocean & Atmosphere (3)
Hydrostatics of the ocean and atmosphere. Vertical stability. Fluid motion in a rotating coordinate system. Geostrophic flow; ocean currents; surface and internal waves. Prerequisites: M.E. 231 or C.E. 121.

326. Aerodynamics (3)
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.

350. Special Topics (3)
A study of some field of engineering mechanics not covered in the general courses. Prerequisite: consent of chairman of department.

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 his graduate program. He may then be required to present a larger number of credits than the minimum required for graduation. A thesis carrying 3 to 6 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 electormechanical interactions. Stress bifringence. 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.

Theory of Thin Shells. Effects of initial stresses on the deformation of thin shells; vibration and stability. Interaction problems of elastic media with electric and magnetic fields. Dynamic response of magnetically excited transducer. Mechanics of tonomety applied to the eye. Construction of a mathematical model for the deformation of the eye.

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)
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 chairman of department.

405. Response of Systems to Random Loads (3)
Stochastic processes; correlation functions and power spectra; response of mechanical systems to one-dimensional and multidimensional random load fields; probability theory for several random variables; statistical properties of the random vibrations of mechanical systems; applications to failure prediction. Prerequisite: consent of chairman of department.

406. Advanced Vibrations (3)
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 chairman of department.

407. Wave Propagation in Solids (3)
Wave propagation in deformable elastic solids; problems in half-space and layered media; application of integral transformations.

409. Theory of Elasticity I (3)
Kinematics of deformation, analysis of stress, stress-strain relations, strain energy function. Reciprocal theorem. Methods for two-dimensional boundary value problems applied to anti-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.

410. Theory of Elasticity II (3)
Advanced topics in the theory of elasticity. The subject matter may vary from year to year and may include, 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 chairman of department.

411. (Phys. 471) Continuum Mechanics (3)
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.

412. Theory of Plasticity (3)
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.

413. Fracture Mechanics (3)
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 chairman of department.

415. (C.E. 468) Stability of Elastic Structures (3)
Basic concepts of instability of a structure; bifurcation, energy increment, snap-through, dynamic instability. Analytical and numerical methods of finding buckling loads of columns. Postbuckling deformations of cantilever 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.

416. Theory of Thin Shells
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.

417. Mixed Boundary Value Problems in Mechanics (3)
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.

421. Fluid Mechanics (3)
Kinematics of fluid flow. Langrangian and Eulerian descriptions. Basic conservation laws. Review of thermodynamics. Constitutive relations. Vorticity, circulations. 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.

422. Fluid Mechanics (3)
Similarity and dimensional analysis. Exact solution for viscous incompressible flow. Singular perturbation theory, with application to flows at low and high Reynolds number. Hydrodynamic stability. Depending on interest, additional topics from magnetohydrodynamics, kinetic theory, wing theory, turbulence, water waves, flows in flexible tubes. Prerequisite: Mech. 421.

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.

437. (Met. 437) Dislocations and Strengths in Crystals (3)
For course description, see Met. 437.

450. Special Problems (3)
An intensive study of some field of applied mechanics not covered in more general courses.

Metallurgy & 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*
Ye Tsang Chou, Ph.D.
Walter Charles Hahn, Jr., Ph.D.
Ralph Wayne Kraft, Ph.D., *New Jersey Zinc Professor*
George Krauss, Jr., Sc.D.
Alan Wiggins Pense, Ph.D.
Richard Moore Spriggs, Ph.D., *Vice President—Administration*
Robert Daniel Stout, Ph.D., *Dean of the Graduate School*
David Alden Thomas, Ph.D., *Associate Director, Materials Research Center*

Associate Professors

Sidney Roy Butler, Ph.D.
Joseph Irwin Goldstein, Ph.D.
D. P. H. Hasselman, Ph.D.
Richard Warren Hertzberg, Ph.D.
Donald M. Smyth, Ph.D., *Director, Materials Research Center*
Stephen Kenneth Tarby, 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 men trained in the science and technology of metals and other materials. The curriculum in metallurgy and materials sciences 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 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 him 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 45)

Sophomore Year, First Semester (16-19 credit hours)†

Math 23	Analytical Geometry and Calculus III (4)
Phys 21, 22	Introductory Physics II & Lab (5)
Eco 1	Economics (4)
Met 63	Engineering Materials and Processes
	or
Met 91	Elements of Materials Science (3)
	Elective (0-3)

Sophomore Year, Second Semester (16-17 credit hours)†

Math 205	Linear Methods
	or
Math 231	Statistical Inference (3)
EE 160	Electrical Circuits and Apparatus
	and
EE 161	Electrical Problems (4)
	or
Phys 31	Introduction to Quantum Mechanics (3)
Mech 1	Statics (3)
Met 10	Metallurgy Lab
	or
Mech 13	Materials Testing Lab (1)
	GS Electives (6)

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)

Junior Year, Second Semester (16-17 credit hours)†

ME 166	Procedures for Mechanical Design (3)
	or
Mech 102	Mechanical Engineering Design (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)†

Chem 196	Physical Chemistry (3)
Met 278	Metallurgical Reports (3)
Met 358	Selection of Materials (3)
Met	Approved Elective (3)
	GS Elective (3)
	Elective (0-3)

†The lower number of credit hours represents the load required to meet graduation requirements; the higher the normal semester load.

*Engineering science electives include, for example, Ch.E. 41, 52, 320, 321; E.E. 11, 20, 103; Mech. 102, 203, 313; Met. 312, 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 the Bethlehem Steel Corporation, and three days per week are spent in the Bethlehem plant for investigation of 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 (3)
Met 307	Structure and Behavior of Materials (3)
Met 313	Materials Fabrication (3)
	Elective (0-3)

Senior Year, Second Semester (17 credit hours)

Chem 196	Physical Chemistry (3)
Met 338	Metallurgy Colloquium (2)
Met 358	Selection of Materials (3)
Met	Approved Elective (3)
	GS Elective (3)
	Engineering Science Elective (3)*

†The lower number of credit hours represents the load required to meet graduation requirements; the higher the normal semester load.

*Engineering science electives include, for example, Ch.E. 41, 52, 320, 321; E.E. 11, 20, 103; Mech. 102, 203, 313; Met. 312, 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 awarded to 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)

Chem 196	Physical Chemistry (3)
Met 338	Metallurgy Colloquium (2)
Met 358	Selection of Materials (3)
Met	Approved Elective (3)
	G.S. Elective (3)
	Engineering Science Elective (3)*

†The lower number of credit hours represent the load required to meet graduation requirements; the higher the normal semester load.

*Engineering science electives include, for example, Ch.E. 41, 52, 320, 321; E.E. 11, 20, 103; Mech. 102, 203, 313; Met. 312, 333, 334.

Undergraduate Courses

10. Metallurgy Laboratory (1)
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)
A study of engineering materials and 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)
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)
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 chairman of the department.

For Advanced Undergraduates and Graduates

207. Electronic and Crystal Structure (3)
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, and Phys. 21.

208. Phase Diagrams and Transformations (3)
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)
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.

218. Mechanical Behavior of Materials (3)
Study of the 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.

240. Research Techniques (2-3)
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)
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 Met. ——— (1-3)

304. Extractive Metallurgy I (4)
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.

305. Extractive Metallurgy II (3)
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. Prerequisites: Met. 304.

307. Structure and Behavior of Materials (3)
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.

312. (Ch.E. 312) Fundamentals of Corrosion (3)
For course description, see Ch.E. 312.

313. Materials Fabrication (3)
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. Prerequisites: Met. 63 or Met. 91, or equivalent.

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. Prerequisite: Chem. 21 and Phys. 11 or consent of chairman of department.

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. Prerequisites: Met. 207 or Phys. 31, or consent of department chairman.

317. Imperfections in Crystals (3)
Study of the types of imperfections in crystals and their effects on the behavior of crytalline materials with particular emphasis on dislocations. Prerequisite: Met. 218.

319. Current Topics in Materials Science (3)
A study of 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 chairman of the department. Prerequisite: Met. 210, 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.

327. Industrial Metallurgy (4)
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.

329. Industrial Metallurgy (4)
To be taken concurrently with Met. 327.

333. (Geol. 337) X-ray Methods (3)
Introduction to the 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.

334. (Geol. 338) Electron Metallography (3)
Study of the fundamentals and experimental methods of electron microscopy, scanning electron microscopy, and electron microprobe analysis. Specific topics include electron optics, electron beam interactions with solids, electron diffraction, chemical microanalysis, and transmission electron microscopy. Applications to the study of the structure of material will be given. Special laboratories will be given in cooperation with other departments as required. Prerequisite: consent of chairman of department.

338. Metallurgical Colloquium (2)
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 chairman of department.

343. (Ch.E. 393, Chem. 393) Physical Polymer Science (3)
For course description, see Ch.E. 393.

358. Selection of Materials (3)
Study of 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 chairman of department.

361. Physics of Materials (3)
Consideration of 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.

362. Structure and Properties of Materials (3)
Study of structure and transformation in materials and correlation of structure with the physical and mechanical behavior of materials. Intended, in conjunction with Met. 361, to provide an integrated background sequence for further studies in the science of materials. Prerequisite: Met. 91 or equivalent.

For Graduates

The department offers three degrees: an M.S. and Ph.D. in Metallurgy and Materials Science, and an M.S. in Materials. This latter degree is part of a special five-year program which

is described on page 156.

There are a diversity of programs and curricula 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 underway in the department or at the Materials Research Center or other departments or centers at Lehigh.

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 or to pass an examination to demonstrate a satisfactory foundation for advanced work.

The programs of the department are flexible. Upon acceptance, each student is assigned a faculty advisor. Under his direction the student plans a course of study to satisfy his 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 earlier in this catalog. In this department, a candidate for the degree of master of science must complete a thesis. This 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 his advisor. Prior to formal establishment of the doctoral program by his special committee and its approval by the graduate school, he 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. A partial listing of such courses may be found under Five-Year Programs. (See page 156.)

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 Graduate School section of this catalog.

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

Effects 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 anisotrophic 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 ultrafine 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. Metallurgical Investigation and 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. Total of 6 credits to be applied to M.S. program.

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 cyrogenic, nuclear, or aerospace fields. This course may be repeated for credit beyond three hours with the permission of the instructor. 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. Prerequisites: consent of chairman of department.

407. Theory of Alloy Phases (3)
Consideration of the application of the principles of thermodynamics, physics, and crystallography to the explanation of structure, physical properties and behavior of crystalline materials. Prerequisite: Met. 208. Desirable preparation: Phys. 363.

408. Transformations (3)
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.

409. Recent Developments in the Theory of Materials (3)
Current topics and theoretical developments in materials. This course may be repeated for credit with permission of the instructor. Prerequisite: consent of the chairman of the department.

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.

411. Modern Joining Methods (3)
The foundations upon which the joining processes rest; the present limitations of the various processes; the trends in new developments; the engineering and structural aspects of joining. Prerequisites: Met. 208 and 218.

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.

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.

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.

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.

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.

418. Deformation and Fracture (3)
Study of 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.

419. Alloy Steels (3)
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.

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 will be discussed. Prerequisites: Math. 205 or 221, or Met. 320; Met. 317, or consent of department chairman.

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 chairman of department.

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.

Modern Foreign Languages and Literatures

Professors

Anna Pirscenok Herz, Ph.D., *Chairman*
Victor Manuel Valenzuela, Ph.D.
John Andrews Van Eerde, Ph.D.

Associate Professor

Arthur Parcel Gardner, Ph.D.

Assistant Professors

Biruta Cap, Ph.D.
Allen E. Hye, Ph.D.
Safeta Juka, Dr. d'Univ.
Anje C. van der Naald, Ph.D.
D. Alexander Waldenrath, Ph.D.

Instructors

Duncan B. Gardiner, M.A.
Alberto Romero, M.A.

Visiting Instructor

Gombilenga Mikongomi, Cert.

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.

Although the minimum requirement for the major is eighteen credit hours of which at least six will be selected from 200-level courses, the normal requirement consists of eight semester courses above the elementary and intermediate levels through which the candidate is expected to gain a knowledge of literature and an adequate command of the language in preparation for the departmental examinations (oral and/or written) and the graduate record examinations.

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, Kiswahili, 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.

Interdisciplinary majors combining a program of Russian studies are encouraged.

Modern Foreign Languages

301. General Linguistics (3)
Historical and descriptive linguistics: emphasis on articulatory phonetics, morphology, and structural grammatical analysis, especially as applied to pedagogy. Conducted in English.

302. The Teaching of a Foreign Language (3)
Conducted in English.

409. Theory of Literary Criticism (3)
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

Eighteen hours of which at least six hours shall be chosen from courses at the 200- or 300-level.

Fr 43, 44	French Oral and Written Composition (6)
Fr 51, 52	Types of French Literature (6)
Fr 53	Balzac (3)
Fr 54	Malraux (3)
Fr 61, 62	17th Century French Literature (6)
Fr 63, 64	18th Century French Literature (6)
Fr 65, 66	19th Century French Literature (6)
Fr 67, 68	20th Century French Literature (6)
Fr 271, 272	Readings
Fr 303	History of French Language (3)
Fr 304	Old French Literature (3)
Fr 307	Baudelaire (3)
Fr 308	Symbolism (3)
Fr 311, 312	French Classicism (6)
Fr 313, 314	The Age of Enlightenment (6)
Fr 315, 316	Late Medieval and Renaissance Literature (6)

Fr 317	The Romantic Movement (3)
Fr 318	Theatre in the Twentieth Century (3)
Fr 319	The New Novel (3)
Fr 331	French Poets of the Twentieth Century (3)
Fr 333	The Great Women Writers of France (3)
Fr 381	French Cultural Program (3-6)

Undergraduate Courses

3. Elementary French (5)
Basic conversational French illustrating essential grammatical principles, reading of simple texts and writing; some laboratory.

4. Intermediate French (5)
A continuation of French 3. Prerequisite: French 3, or Achievement Test score before entrance, or consent of chairman of department.

13. Advanced French (4)
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)
Emphasis on readings and discussion. Prerequisite: Fr. 3, or Achievement Test score before entrance, or consent of chairman of department.

43. French Oral and Written Composition (3)
For students who wish a greater opportunity for practice in the oral and written use of French than can be provided in the literature courses. Prerequisites: Fr. 14, or consent of department chairman, or Achievement Test score of 600.

44. French Oral and Written Composition (3)
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.

51. A Survey of French Literature (3)
Training in the ability to read and understand representative works from the Middle Ages to the nineteenth century. Outside reading and reports. Conducted in French. Prerequisites: Fr. 42 or 4 units of entrance French or consent of chairman of department.

52. A Survey of French Literature (3)
Reading and discussion of representative works of the nineteenth and twentieth centuries. Outside reading and reports. Conducted in French. Prerequisites: Fr. 51 or consent of chairman of department.

53. Balzac (3)
Conducted in French. Prerequisite: consent of chairman, Fr. 14 and 42, or Achievement Test score of 600.

54. Malraux (3)
Conducted in French. Prerequisite: consent of chairman, Fr. 14 and 42, or Achievement Test score of 600.

61. Seventeenth Century French Literature (3)
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. Prerequisites: Fr. 51-52 or 5 units of entrance French, or consent of chairman of department.

62. Seventeenth Century French Literature (3)
Continuation of Fr. 61. Conducted in French. Prerequisite: Fr. 61, or consent of the chairman of the department.

63. Eighteenth Century French Literature (3)
The literature of the Enlightenment and pre-Romanticism. Lectures, discussion of texts, reports, and collateral readings. Conducted in French. Prerequisites: French 51-52, or 5 units of entrance French, or consent of chairman of department.

64. Eighteenth Century French Literature (3)
Continuation of Fr. 63. Prerequisite: Fr. 63, or consent of chairman of department.

65. Nineteenth Century French Literature (3)
Main literary currents of the nineteenth century; Romanticism and Realism. Lectures, reports, collateral readings. Prerequisites: Fr. 51-52, or 5 units of entrance French, or consent of chairman of department.

66. Nineteenth Century French Literature (3)
Continuation of Fr. 65. Prerequisite: Fr. 65, or consent of chairman of department.

67. Twentieth Century French Literature (3)
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. 51-52 or consent of the chairman of department.

68. Twentieth Century French Literature (3)
A study of the drama and poetry of 20th 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 chairman of department.

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 18 credit hours, 15 of which are to be selected from the department's 400-level course offerings. He may choose to submit a thesis representing the equivalent of a maximum of 6 hours of course work. If desired, the candidate is permitted to take collateral work in related fields to the extent of 12 semester hours. At the end of his course work he shall be asked to pass a comprehensive examination.

271. Readings (3)
A study of the works of some author or group of authors, or of a period. Prerequisite: Fr. 41-42 or 51-52 or consent of chairman of department.

272. Readings (3)
Continuation of Fr. 271. Prerequisite: Fr. 271 or consent of chairman of department.

303. History of the French Language (3)
A chronological history of the origins and development of the French language, from the beginnings to the present. Particular stages of the development of the language will be analyzed: Gallo-Romance, Old French, Middle French, Renaissance, Classicism, Romanticism, and Contemporary French. Vocabulary, pronunciation, and structure will be treated. Conducted in English. Prerequisite: Fr. 51-52, or consent of chairman of department.

304. Old French Literature (3)
Readings in French literature of the Middle Ages, particularly representative works of the literary renaissance of the twelfth century: *chanson de geste*, lyric poetry and *roman d'aventure*. Longer treatment will be given to the Arthurian romances, especially the works of Chrestien de Troyes. Lectures, discussions, and reports. Some of the readings will be in the original Old French, some in modern French translations. Conducted in English. Prerequisite: Fr. 51-52, including a thorough reading knowledge of the language, or consent of the chairman of the department.

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 chairman of department.

308. Symbolism (3)
An intensive study of the symbolist school of poetry following Baudelaire through Mallarme and the end of the 19th century.

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 chairman of department.

312. French Classicism (3)
Continuation of Fr. 311. Conducted in French. Prerequisite: Fr. 311 or consent of chairman of department.

313. The Age of Enlightenment (3)
A study of the "Philosophes" and "Encyclopedistes" of the 18th century, with emphasis on Voltaire, Rousseau, Montesquieu, and Diderot. Conducted in French. Prerequisite: Fr. 51-52 or consent of chairman of department.

314. The Age of Enlightenment (3)
Continuation of Fr. 313. Conducted in French. Prerequisite: Fr. 313 or consent of chairman of department.

315. Late Medieval and Renaissance Literature (3)
Readings, study, and discussion of French prose and dramatic literature of the fifteenth and sixteenth centuries. Lectures, reports, and class discussion. Conducted in French. Prerequisite: Fr. 52 or consent of chairman of department.

316. Late Medieval and Renaissance Literature (3)
Readings and analysis of representative lyric poetry from the Troubadors to the Pleiade. Lectures, reports, and class discussions. Conducted in French. Prerequisite: Fr. 51 or consent of chairman of department.

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 chairman of department.

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 chairman of department.

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 chairman of department.

321. French Literature in Translation (3)
The most significant works in French literature with a certain emphasis on those that relate to other literatures, especially those written in Romance languages. No knowledge of French is required. French 321 cannot count as a language course. Prerequisite: a college course in literature, or consent of chairman of department.

322. French Literature in Translation (3)
A continuation of Fr. 321. Fr. 322 cannot count as a language course. Prerequisite: Fr. 321, or consent of chairman of department.

331. French Poets of the Twentieth Century (3)
The leading poets from Valery to Bonnefoy. Conducted in French. Prerequisite: consent of chairman or two semesters of French literature in college.

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 chairman or two semesters of French literature in college.

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.

411. Voltaire (3)
Representatives readings. Conducted in French. Prerequisite: a 300-level course or equivalent, or consent of chairman of department.

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 chairman of department.

413. French Heritage (3)
After a brief introductory survey of the development of France from prehistoric times to the Middle Ages, French culture will be studied more comprehensively through political history, successive changes in social structures and mores, especially as they appear in literature and art. Conducted in French. Prerequisite: a 300-level course or equivalent or consent of chairman of department.

414. French Heritage (3)
Continuation of Fr. 413. Prerequisite: Fr. 413, or consent of chairman of department.

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 the chairman of the department.

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 chairman of department.

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 chairman or a 300-level course in French literature.

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 chairman of department.

420. Surrealism (3)
The contributions of Breton, Aragon, Elnard, Desnes, and others. Relations between painting and poetry. Conducted in French. Prerequisite: consent of chairman or a 300-level course in French literature.

422. French Satirical Literature (3)
A survey from the Middle Ages to the present. Conducted in French. Prerequisite: consent of chairman or a 300-level course in French literature.

491. Independent Study (1-3)
Special topics to supplement other study for the M.A. degree. Conducted in French. Prerequisite: a 300-level course or equivalent, or consent of chairman of the department.

492. Independent Study (1-3)
Special topics to supplement other study for the M.A. degree. Conducted in French. Prerequisite: a 300-level course or equivalent, or consent of chairman of department

German

Required Preliminary Courses

Ger 3	Elementary German (5)
Ger 4	Intermediate German (5)
Ger 13	Types of German Literature (4)
	or
Ger 31	Conversation and Composition (3)
Ger 14	Types of German Literature (3)
	or
Ger 32	Conversation and Composition (3)

Required Major Courses

Ger 52	Goethe's Faust (3)

And at least two of the following:

Ger 250, 251	Special Topics (6)
Ger 303	German Romanticism (3)
Ger 305	Twentieth Century German Literature (3)
Ger 311	Introduction to Lyric Poetry (3)
Ger 321	Nineteenth Century German Literature (3)
Ger 341	Advanced Conversation and Composition (3)

Ger 344	The Age of Goethe (3)
Ger 352	Survey of Older German Literature (3)

A senior comprehensive examination is required.

Undergraduate Courses

3. Elementary German (5)
Fundamentals of German grammar; pronunciation; simple conversation and composition; reading of simple texts. No previous German required.

4. Intermediate German (5)
Review of grammar; composition; reading and discussion of intermediate texts. Prerequisite: German 3, or 2 units of entrance German, or consent of chairman of department.

6. Scientific German (3)
Readings in chemistry and physics. Prerequisite: Ger. 1, or two units of entrance German.

13. Types of German Literature (4)
Reading and discussion in German of advanced texts. Prerequisite: German 4, or 3 units of entrance German, or consent of chairman of department.

14. Types of German Literature (3)
Continuation of Ger. 13. Prerequisite: Ger. 4, or Ger. 13, or consent of chairman of department.

31. Conversation and Composition (3)
Exercises in grammar; phonetics; conversation and composition stressing situations taken from daily life. Prerequisites: Ger. 12 or four units of entrance German.

32. Conversation and Composition (3)
Continuation of Ger. 31. Oral and written reports, personal and business letters, fundamentals of good style. Prerequisite: Ger. 31 or Ger. 43.

52. Goethe's Faust (3)
Reading of the Faust drama and collateral materials. Prerequisite: Ger. 31 or 43, or consent of chairman of department.

101. The European Drama (3)
Readings and live theater performances in Germany. Prerequisite: 3 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: German 101 or its equivalent.

103. Supplemental Language Practice (1)
Prerequisite: 3 semesters of college German or the equivalent. This course must be taken concurrently with German 101.

111. Humanities in Germany (1-4)
Formal participation in approved courses in some branch of the humanities for a semester at a German university. Prerequisite: German 102 or its equivalent.

112. Humanities in Germany (1-4)
Continuation of German 111. Prerequisite: German 102 or its equivalent.

113. Humanities in Germany (1-4)
Continuation of German 112. Prerequisite: German 102 or its equivalent.

114. Humanities in Germany (1-4)
Continuation of German 113. Prerequisite: German 102 or its equivalent.

121. Social Science in Germany (1-4)
Formal participation in approved courses in some branch of the social sciences for a semester at a German university. Prerequisite: German 102 or its equivalent.

122. Social Sciences in Germany (1-4)
Continuation of German 121. Prerequisite: German 102 or its equivalent.

123. Social Sciences in Germany (1-4)
Continuation of German 122. Prerequisite: German 102 or its equivalent.

124. Social Sciences in Germany (1-4)
Continuation of German 123. Prerequisite: German 102 or its equivalent.

131. Sciences in Germany (1-4)
Formal participation in approved courses in some branch of the sciences for a semester at a German university. Prerequisite: German 102 or its equivalent.

132. Sciences in Germany (1-4)
Continuation of German 131. Prerequisite: German 102 or its equivalent.

133. Sciences in Germany (1-4)
Continuation of German 132. Prerequisite: German 102 or its equivalent.

134. Sciences in Germany (1-4)
Continuation of German 133. Prerequisite: German 102 or its equivalent.

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 10 semester courses (30 credit hours) is required for the M.A. degree. A thesis may be offered in lieu of two semester courses (6 credit hours). Collateral graduate work in other departments may be taken upon consultation with the chairman of the department.

The prerequisite for all 200-level courses is three years of college German or the equivalent, or consent of chairman of the department.

250. Special Topics (1-3)
Study of literary and linguistic topics not covered in regular courses, or continuation of study of topics begun in regular courses. May be repeated for credit.

251. German Culture and Civilization (3)
A study of German customs, institutions, and cultural contributions to western civilization. No knowledge of German required. German majors and graduate students must write a research paper in German.

303. German Romanticism (3)
Early and late Romanticists. Prerequisites: Ger. 31, 32, 43, or 44, or consent of chairman of department.

305. Twentieth Century German Literature (3)
Study of works by representative writers from Naturalism through the end of World War II. Prerequisite: 3 years of college German (or equivalent) or consent of chairman of the department.

311. Introduction to Lyric Poetry (3)
Selected poems from the beginning to the modern periods. Discussion and analysis. Prerequisite: three years of college German, or equivalent, or consent of the chairman of the department.

321. Nineteenth Century German Literature (3)
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. Prerequisites: Ger. 31, 32, 43, 44 or consent of chairman of department.

341. Advanced Conversation and Composition (3)
For undergraduates and teachers. Prerequisites: German 31 or 32, or consent of chairman of department.

344. The Age of Goethe (3)
Selected works from Klopstock to Holderlin; with special emphasis on Herder, Goethe and Schiller. Prerequisite: German 31 or 43 or 44, or consent of chairman of department.

352. Survey of Older German Literature (3)
Survey of older German literature from the beginning to the Renaissance. Prerequisite: a 200- or 300-level course in German or consent of chairman.

381. Cultural Studies (3-6)
A program in German-speaking Europe, during the summer, for in-service teachers of German and advanced or graduate students.

411. George, Rilke and Hofmannsthal (3)
Study of works by three major figures in German literature between 1890 and 1933. Prerequisite: three credit hours in German at the 300-level.

421. Renaissance and Baroque (3)
German literature from *Der Ackermann aus Bohmen* to the Age of Enlightenment. Prerequisite: three credit hours in German at the 300-level.

431. Lessing and the Enlightenment (3)
Discussion and analysis of the literature in the pre-Classical Age. Prerequisite: three credit hours in German at the 300-level.

441. Middle High German (3)
A study and an analysis of the language and some of the outstanding writers in their work. Prerequisite: three credit hours in German at the 300-level.

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.

491. Thesis (3)

492. Thesis (3)

Italian

1. Elementary Italian (3)
Grammar; composition; rapid reading of easy modern prose. No previous study of Italian required.

2. Elementary Italian (3)
Continuation of Ital. 1. Prerequisite: Ital. 1.

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.

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.

Kiswahili

1. Elementary Kiswahili (3)
An intensive course in vocabulary and pronunciation as well as verb drills based on modern Kiswahili geared to the needs of an American student in understanding and appreciating both the structure of the language and its cultural aspects.

2. Elementary Kiswahili (3)
Continuation of Ksw. 1. Further practice in verb drills, pronunciation, and vocabulary build up. Prerequisite: Ksw. 1, or consent of chairman of department.

11. Intermediate Kiswahili (3)
Exercises in grammar; conversation and composition based on situational East African daily life. Prerequisite: Ksw. 2, or consent of chairman of department.

12. Intermediate Kiswahili (3)
Continuation of Ksw. 11 with more emphasis on composition: fundamentals of good style, essays, letter writing; oral and written reports; modern Kiswahili readings, and a short survey of 18th and 19th century Kiswahili literature. Prerequisite: Ksw. 11 or consent of the chairman of the department.

Portuguese

1. Elementary Portuguese (3)
A study of Portuguese grammar and forms; practice in writing and speaking Portuguese.

2. Elementary Portuguese (3)
Continuation of Port. 1. Prerequisite: Port. 1.

Russian

3. Elementary Russian (5)
Classroom and laboratory introduction to the fundamentals of conversational and grammatical patterns; practice in pronunciation, simple conversation, reading and writing.

4. Elementary Russian (5)
Continuation of Russian 3. Prerequisite: Russian 3 or 2 units of entrance Russian.

13. Intermediate Russian (4)
Classroom and laboratory practice in conversation. Development of reading and writing skills. Prerequisite: Russian 4, or 3 units of entrance Russian, or consent of chairman of department.

14. Intermediate Russian (3)
Continuation of Russian 13. Prerequisite: Russian 4 or 13, or 3 units of entrance Russian, or consent of chairman of department.

41. Conversation and Composition (3)
Intensive practice in oral and written Russian; laboratory practice in aural comprehension. Readings and discussions on Russian literature and culture. Prerequisite: Russian 12, or 3 units of entrance Russian, or consent of chairman of department.

42. Conversation and Composition (3)
Continuation of Russian 41. Prerequisite: Russian 41 or consent of chairman of department.

251. Special Topics (3)
Intensive study of literary or linguistic topics. Prerequisite: Russian 42, or consent of chairman of department.

252. Special Topics (3)
Continuation of Russian 251. Prerequisite: Russian 251, or consent of chairman of department.

341. Russian Realism (3)
Selected works by the Russian realists of the 19th 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.

343. Contemporary Soviet Literature (3)
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.

Spanish

Required Preliminary Courses

Span 3	Elementary Spanish (5)
Span 4	Intermediate Spanish (5)
Span 13	Intermediate Spanish (4)
Span 14	Advanced Spanish (3)

Required Courses in Major

Eighteen hours from the following of which at least six shall be chosen from courses at the 200- or 300-level.

Span 51	Cultural Evolution of Spain (3)
Span 52	Cultural Evolution of Latin America (3)
Span 61	Survey of Contemporary Spanish Literature from Generation of 98 to the Present (3)
Span 62	Women Poets of Latin America (3)
Span 63	Introduction to Spanish Literature up to 1700 (3)
Span 64	Introduction to Spanish Literature from 1700 to the Present (3)
Span 271, 272	Readings (6)
Span 301	The Spanish Essay (3)
Span 302	The Latin American Essay (3)

Span 303	Cervantes (3)
Span 305	Spanish Literature in the Middle Ages (3)
Span 306	Latin American Literature Since World War II (3)
Span 307	The Golden Age (3)
Span 308	Spanish Literature Since the Civil War (3)
Span 309	Sixteenth Century (3)
Span 310	Nineteenth Century Spanish Novel (3)
Span 311	The Generation of 98 (3)
Span 321	Latin American Literature in Translation (3)
Span 322	Latin American Literature in Translation (3)
Span 331	Spanish American Literature (3)
Span 332	Spanish American Literature (3)
Span 381	Summer Session in Spain (6)

Undergraduate Courses

3. Elementary Spanish (5)
Basic conversational Spanish illustrating essential grammatical principles, reading of simple texts and writing.

4. Intermediate Spanish (5)
A continuation of Spanish 3. Prerequisite: Span. 3 or consent of section head.

13. Intermediate Spanish (4)
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. 4 or consent of section head.

14. Advanced Spanish (3)
A continuation of Spanish 13. Emphasis on readings and discussion. Prerequisite: Span. 13 or consent of section head.

51. Cultural Evolution of Spain (3)
The historical and cultural evolution of Spain from its beginning to the present. Conducted in Spanish. Prerequisite: Span. 14 or consent of section head.

52. Cultural Evolution of Latin America (3)
The historical and cultural evolution of Latin America. Conducted in Spanish. Prerequisite: Span. 51 or consent of section head.

61. Survey of Contemporary Spanish Literature from the Generation of 98 to the Present (3)
A study of the development of the literature of Spain from the Generation of 98 to the present. Conducted in Spanish. Prerequisite: consent of section head.

62. Women Poets of Latin America (3)
Reading and discussion of the works of Sor Juana I. de la Cruz, Storni, Agustini, Vaz Ferreira, Ibarborou, Gabriela Mistral, et al. Conducted in Spanish. Prerequisite: consent of section head.

63. Introduction to Spanish Literature up to 1700 (3)
Systematic study of Spanish literature from the Middle Ages to 1700. Representative writings of each period will be read and analyzed. Lectures, discussion. Conducted in Spanish. Prerequisite: consent of section head.

64. Introduction to Spanish Literature from 1700 (3)
Continuation of Spanish 63, focusing on Spanish literature since 1700. Conducted in Spanish. Prerequisite: consent of section head.

81. Summer Session in Spain (3-6)
A summer program abroad. Includes formal instruction in the Spanish language as well as direct contact with the Spanish people and their culture.

271. Readings (3)
A study of the works of some author or group of authors or of a period. Prerequisite: consent of section head.

272. Readings (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)
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 Spanish 51.

302. The Latin American Essay (3)
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 Spanish 52.

303. Cervantes (3)
Reading and critical study of the chief works of Miguel de Cervantes with special emphasis on *Don Quijote*. Collateral reading and reports. Given in Spanish. Prerequisite: Span. 51 or consent of section head.

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.* Given in Spanish. Prerequisite: Span. 51 or consent of section head.

306. Latin American Literature Since World War II (3)
Reading and discussion of representative works of contemporary Latin American authors. Given in Spanish. Prerequisite: Span. 52 or consent of section head.

307. The Golden Age (3)
A study of the representative works of the authors of the XVII century. Given in Spanish. Prerequisite: Span. 51 or consent of section head.

308. Spanish Literature Since the 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.

309. Sixteenth Century (3)
Representative readings. Conducted in Spanish. Prerequisite: Span. 51 or consent of section head.

310. Nineteenth Century Spanish Novel (3)
Realism and Naturalism in Spain. Conducted in Spanish. Prerequisite: Span. 51 or consent of section head.

311. The Generation of 98 (3)
A study of the outstanding works by the writers of the Generation. Conducted in Spanish. Prerequisite: Span. 51 or consent of section head.

321. Latin American Literature in Translation (3)
Reading and discussion of outstanding works of Latin American literature in translation to provide insight into Latin American culture. No knowledge of Spanish is required. Spanish 321 cannot count as a language course. Prerequisite: consent of section head.

322. Latin American Literature in Translation (3)
Reading and discussion of outstanding works of Latin American literature in translation to provide insight into Latin American culture. No knowledge of Spanish is required. Spanish 322 cannot count as a language course. Prerequisite: consent of section head.

331. Spanish American Literature (3)
Reading and discussion of representative works of the literature of the Pre-Columbian, Conquest and Colonial periods. Oral and written reports. Term paper. Conducted in Spanish. Prerequisite: Span. 51, 52 or consent of section head.

332. Spanish American Literature (3)
Reading and discussion of representative works of the literature of the nineteenth and twentieth centuries. Oral and written reports. Term paper. Conducted in Spanish. Prerequisite: Span. 51, 52 or consent of section head.

341. Conversational Spanish (3)
Practice in fluency and accuracy in Spanish. Prerequisite: consent of instructor.

342. Spanish Composition (3)
Practice in Spanish composition; special attention to syntax and style. Prerequisite: consent of instructor.

381. Summer Study in Spain
A summer program in Spain offering formal language courses and cultural opportunities to graduate students and teachers of Spanish.

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.

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.

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.

414. Twentieth Century Spanish Poetry before the Civil War (3)
Readings of the poetry of Unamuno, Antonio Machado, Juan R. Jimenez and the poets of the generation of 1927. Conducted in Spanish. Prerequisite: a 300-level course or consent of section head.

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.

417. Seminar on Galdos (3)
A study of the life and works of Perez Galdos. Conducted in Spanish. Prerequisite: a 300-level course or equivalent, or consent of section head.

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 equivalent, or consent of section head.

419. Nineteenth Century Spanish Theater (3)
From Romanticism to Realism in 19th century Spain. Conducted in Spanish. Prerequisite: a 300-level course or consent of section head.

491. Independent Study (3)
Special topics to supplement other study for the M.A. degree. Conducted in Spanish. Prerequisite: a 300-level course or equivalent, 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 equivalent, or consent of section head.

Music

Professors

Robert Benjamin Cutler, M.A., *Chairman*
Jonathan Britton Elkus, M.A.

The aim of the music curriculum is to develop musical skills and musicality, and to prepare students for admission to graduate work in music. The major is based on courses offered both at Lehigh and Moravian College; the greater portion of the curriculum is currently taught at Moravian College.

A major concentration in music consists of thirty credit hours, twenty-four of which shall be advanced courses. The Moravian courses in Fundamentals, Music 1 and 2, are required for students who have not mastered the rudiments of music.

Students must demonstrate their ability in sight-singing and dictation, and must be able to play major and minor scales and harmonic progressions in all keys, and to read chorales in open score and from figured bass.

All majors are required to participate regularly in one or more of the Lehigh University or Moravian College performing organizations or ensembles. Qualified students present recitals.

Majors may earn credit for private instruction. Fees must be borne by the students.

Courses Offered at Moravian College

1-2. Fundamentals (4)
Hearing the materials of music, notation, dictation, sight-singing and musicianship. Prerequisite: consent of instructor and chairman of Lehigh department. Five 50-minute periods.

101. Music before 1600 (3)
Music literature from its earliest evidence through the Renaissance. Extensive score analysis and listening. Prerequisite: Music 1 and consent of instructor and chairman of Lehigh department. Two 70-minute periods.

102. The Seventeenth and Eighteenth Centuries (3)
Music literature of the Baroque, Rococo and Classic periods. Extensive score analysis and listening. Prerequisite: Music 1 and consent of instructor and chairman of Lehigh department. Two 70-minute periods.

103. The Nineteenth Century (3)
Beethoven and his romantic heirs. Extensive score analysis and listening. Prerequisite: Music 1 and consent of instructor and chairman of Lehigh department. Two 70-minute periods.

104. The Twentieth Century (3)
Post-romanticism, impressionism, atonality, dodecaphony, experimentalism. Prerequisite: Music 1 and consent of instructor and chairman of Lehigh department. Two 70-minute periods.

121. Modal Counterpoint (2)
Theory integrated with Music 101. A study of Medieval melody. Writing organum and motet-madrigal contrapuntal style. Prerequisite: Music 2 and consent of instructor and chairman of Lehigh department. Three 50-minute periods.

122. Traditional Contrapuntal-Harmonic Practice (2)
Theory integrated with Music 102. Writing and playing chords and harmonic progressions. Dominant-tonic relationship and its extension. Association of voices, contrapuntal devices and textures. Prerequisite: Music 2 and consent of instructor and chairman of Lehigh department. Three 50-minute periods.

123. Chromatic Harmony (2)
Theory integrated with Music 103. The tonal harmonic perspective culminating in the music of Wagner. Prerequisite: Music 2 and consent of instructor and chairman of Lehigh department. Three 50-minute periods.

124. Contemporary Techniques (2)
Theory integrated with Music 104. Working with compositional ideas that approach a common usage. Manipulating sound formations expressively. Prerequisite: Music 2 and consent of instructor and chairman of Lehigh department. Three 50-minute periods.

141-142. Instrumental Techniques I (1)
Beginning class instruction in playing band and orchestral instruments with emphasis on teaching and learning. Principal instruments include flute, clarinet, trumpet, horn, trombone, snare drum, violin, cello. Prerequisite: Music 1 or equivalent and consent of instructor and chairman of Lehigh department. Two 50-minute periods.

151-152. Instrumental Techniques II (1)
Continuation of Techniques I. Prerequisite: Music 1 or equivalent and permission of instructor and chairman of Lehigh department. Two 50-minute periods.

212-213. Conducting (2)
Technique and expression in conducting. Score study of choral and instrumental literature. Rehearsal procedures. Field trip observation. Prerequisite: Music 122 or 123. Two 70-minute periods.

223. Orchestration (2)
Integrated with Music 213. Instrumental characteristics, nomenclature, and notation. Score analysis, scoring and arranging. Prerequisite: Music 122 or 123. Two 70-minute periods.

Performance (Open to Majors Only)

The department offers private instruction in piano, voice, organ, harpsichord, recorder, composition, brass, string, woodwind and percussion instruments. These courses may be elected by students who first satisfy the department that they are prepared to undertake the study or writing of music literature of artistic worth. One credit hour is given for each semester.

In each performing area instruction entails comprehensive repertory, necessary technical study, sight reading, and musicality. Weekly lessons and practice are scheduled, and attendance at stated performance classes, recitals, and concerts is required. The department may require a student to enroll in one or more courses which would strengthen and complement his proficiency.

Each term of private instruction carries one credit hour. When registering, the student lists the course in Performance as follows: Music: P-name of instrument, and 1, 2, 3, etc. to indicate number of terms of study on the instrument. Example: "Music: P-Clarinet, 4" (fourth term of private study of clarinet).

Fees for private instruction must be borne by the student.

Courses Offered at Lehigh

1-4. Instrumental Music (1)
Study and performance of instrumental music. Participation in the appropriate ensemble, as determined by the department of music, is an integral part of the course. Students enrolling for their first semester register for Mus. 1; for their second, Mus. 2, etc. Prerequisite: consent of chairman of department.

5-8. Choral Music (1)
Study and performance of choral music. Participation in the appropriate vocal ensemble, as determined by the department of music, is an integral part of the course. Students enrolling for their first semester register for Mus. 5; for their second, Mus. 6, etc. Prerequisite: consent of chairman of department.

9. Instrumental Music (0)
Study and performance of instrumental music. Participation in the appropriate ensemble, as determined by the department of music, is an integral part of the course. May be repeated. Prerequisite: consent of chairman of department.

10. Choral Music (0)
Study and performance of choral music. Participation in the appropriate ensemble, as determined by the department of music, is an integral part of the course. May be repeated. Prerequisite: consent of chairman of department.

20. Introduction to Musical Literature (3)
An approach to musical style through the study of works by representative composers from 1600 to the present.

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 chairman of department.

142. Chamber Music (3)
A survey of works for smaller instrumental ensembles from the forerunners of Haydn to Stravinsky. Prerequisite: consent of chairman of department.

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 chairman of department.

144. Aesthetics and Criticism of Music (3)
An analytical approach to writings of Hanslick, Nietzsche, Stravinsky, Thomson, Langer, and others with particular attention to the questions of meaning, intent, and expressive values in music. Prerequisite: consent of chairman of department.

145. The Viennese Classic Period (3)
Exercises in musical composition in the manner of eighteenth century common practice; analysis of musical examples. Knowledge of conventional musical notation required. Prerequisite: consent of chairman of department.

146. Viennese Classical Period (3)
Intensive study of works of various media of Haydn, Mozart and Beethoven, with emphasis on form and style. Prerequisite: consent of chairman of department.

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 chairman of department.

The Lehigh University Band

Band may be elected by suitably qualified undergraduates. The band will consist of a concert, varsity, and marching band and will perform music, as specified by the director, for concerts, convocations, and athletic events.

Except during the fall season, rehearsals will be held twice weekly and, in addition, provision may be made for required section rehearsals.

Band uniforms and certain musical instruments are furnished by the University. A deposit of $25 is required from each member of the band for the uniform issued him. Members of the Concert Band will purchase their own blazers, which are worn for certain performances.

Students serving in the band receive the following awards: a sweater for two years of satisfactory service; for three years, $20 in cash; and four years, an additional $20 in cash.

The Lehigh University Glee Club

Glee Club may be elected by suitable qualified undergraduates.

Traditionally, the Glee Club has been a men's chorus. In addition to performing its own repertoire, it collaborates with choruses of women's colleges in performing major works with orchestra, on the campus and away.

The Glee Club invites qualified women to participate in its activities and to contribute to the development of new choral programs on the campus.

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.), and (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 Professor J. Donald Ryan, department of geological sciences, 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 his major advisor.

A special program leading to a B.A. in Natural Science and an M.S. 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 only one year of study beyond the baccalaureate.

Required Preliminary Courses

Math 1, 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.

A student registered for this major normally is expected to choose his option no later than the second semester of his sophomore year.

Philosophy

Division of Philosophy

Professors

Thomas Morris Haynes, Ph.D.

Associate Professors

Robert Featherstone Barnes, Ph.D.
John Ralph Lindgren, Ph.D., *Head, Division of Philosophy*
Norman Paul Melchert, Ph.D.

Assistant Professors

Nicholas Anthony LaPara, Ph.D.

Students considering a philosophy major need answers to two main questions: What is the field of philosophy like? And what career possibilities are there for someone who majors 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 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? What human life styles 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 critique of those proposals are the actual elements of philosophical investigation.

A major in 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 not considering such fields will find a wide range of other careers open to them by majoring in philosophy or including philosophy in

an interdisciplinary or double major. Capable philosophy students who choose their electives wisely find that the analytical, logical, and discursive skills provided by philosophical training enable them to pursue successfully careers after graduation in such fields as communications, publishing, insurance, marketing, merchandising, social services, advertising, transportation, and utilities.

The curriculum for the philosophy major consists of a basic framework of required courses and approved electives. The required courses provide each student with a direct acquaintance with the works of major thinkers who have proved to be both influential in shaping our world and useful as models for our own philosophical thinking. The approved electives provide a context for focusing and further developing analytical and critical skills according to each student's interests and goals. The range and flexibility of the major curriculum combines with close contact with departmental faculty to provide each student with the opportunities for both tailoring programs to his or her own personal goals and laying the foundations for continued learning throughout life.

Required Courses

Phil 14	Foundations of Logic (3)
Phil 15	Ethics (3)

Plus three of the following:

Phil 231	Ancient Philosophy (3)
Phil 235	17th and 18th Century Philosophy (3)
Phil 237	19th Century Philosophy (3)
Phil 241	20th Century Continental Philosophy (3)
Phil 242	20th Century Anglo-American Philosophy (3)

And fifteen hours to be selected with the counsel and approval of 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

11. Values, the Individual, and the State: An Introduction to Philosophical Thinking (3)
An introductory course with two goals: (1) to explore some important current issues such as the objectivity of values; the moral status of the state; the obligation, if any, to obey the law; 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 instructor required.

14. Foundations of Logic (3)
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.

15. Ethics (3)
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)
A study of the ways in which scientific conceptions of nature are generated. Study of the historical development of some landmark achievements in science provides the background for understanding the logic of this intellectual activity.

100. Philosophy of Contemporary Civilization (3)
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.

For Advanced Undergraduates and Graduates

231. Ancient Philosophy (3)
A historical study of philosophy in ancient times from its origin in Ionia through its flowering with Plato and Aristotle to its decline with the Roman Stoics and Neo-Platonists. Special attention will be given to the interaction of religious, political and scientific thought with philosophy during the period.

235. 17th and 18th Century Philosophy (3)
A historical study of the major philosophies from the Renaissance to the end of the 18th century; the work of Descartes, Spinoza, Leibniz, Locke, Berkeley, Hume, Rousseau, and Kant. Special attention will be given to the interaction of scientific and philosophical thought during the period.

237. 19th Century Philosophy (3)
A historical study of the major philosophers of the last century, including Mill, Hegel, Feuerbach, Marx, and Nietzsche. Special emphasis will be given to such issues as social philosophy, the philosophy of history and theory of knowledge.

241. 20th Century Continental Philosophy (3)
The main philosophical trends in Europe in this century: phenomenology, existentialism, and Marxism. Readings from the work of Husserl, Heidegger, Sartre, Camus, Buber, Lenin, and others.

242. 20th Century Anglo-American Philosophy (3)
The main philosophical trends in England and America in this century: pragmatism, realism, analysis, logical positivism, ordinary language philosophy, and the move beyond traditional empiricism. Readings from Peirce, James, Dewey, Moore, Russell, Ayer, Whitehead and others.

243. Kierkegaard (1)
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.

251. Philosophy of Religion (3)
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.

261. Introduction to Philosophy of Science (3)
An analysis of scientific concepts and the structure of scientific knowledge. Topics investigated are explanation, empirical significance, theory and fact, observation, operationalism, behaviorism; cause, disposition, and law; determinism, emergence, and the human mind; science and value. Philosophy majors will also study probability and induction.

271. Readings in Philosophy (1-3)
A course of readings designed primarily for undergraduate philosophy majors. Prerequisite: consent of head of division.

272. Readings in Philosophy (1-3)
A course of readings designed primarily for undergraduate philosophy majors. Prerequisite: consent of head of division.

301. Philosophy of the Social Sciences (3)
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.

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.

310. Social Philosophy (3)
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.

314. Logic (3)
A study of the syntactic and semantic methods of modern logic and the relationships between them. Special attention will be given to the philosophical significance of the major results in the field.

315. Contemporary Ethics (3)
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 the instructor.

333. Marxist Philosophers (3)
A historical study of philosophers in the Marxist tradition including Marx, Engels, Kautsky, Plekhanov, Bernstein, Lenin, Lukacs, Stalin and Mao. Primary sources emphasized.

350. Philosophy of Mind (3)
An examination of classical and current literature on the concept of mind: mind and body, the other minds problem, free will and determinism, minds and machines.

362. Issues in the Philosophy of Science (3)
Critical study and review of crucial philosophical problems arising from research into the logical and epistemological foundations of science, with attention directed at alternative approaches to their resolution. Prerequisite: Phil. 261 or consent of head of division.

364. Philosophy of Language (3)
Investigation of the problems centering around the question of how language, a conventional and arbitrary structure of symbols, can be a vehicle of meaning, thought, and concept. Among these problems are those concerning the source of meaning, reference and meaning, truth and fact, necessary truth, truth by convention, and the nature of conventions and linguistic rules.

388. Philosophy of Mathematics (3)
An investigation of the philosophical foundations of mathematics, with special emphasis on the "classical" views of the nature of mathematics—logicism, formalism, and intuitionism—and on their contempory counterparts.

391. Senior Seminar (3)
Examination of selected topics for philosophy majors and other advanced students. Prerequisite: consent of instructor.

Division of Information Science

Professors

Donald John Hillman, M.Litt., *Chairman, Department of Philosophy, Head, Division of Information Science, Director, Center for Information Sciences*
Herbert Rubenstein, Ph.D.

Associate Professors

Robert Featherstone Barnes, Ph.D.
Andrew James Kasarda, Ph.D.
John J. O'Connor, Ph.D.

Assistant Professors

James Sproat Green, Ph.D.
Louis W. Stern, Ph.D.

The rate of change in information technology demands that the practitioner have the conceptual background necessary to participate in and contribute to existing and developing systems. Within this framework, the M.S. and Ph.D. degree programs offered by the division of information science are designed to fulfill several objectives. Each program provides a broad base of both theory and application. Emphasis is on fundamentals, rather than techniques. Basic to the program of information science at Lehigh University is the concept that research and instruction reinforce one another. Consequently whenever possible, students are expected to participate in research and operations on a part-time basis.

The curriculum in information science is based on a B.S. degree in an engineering or scientific discipline. Desirable preparation consists of at least 12 hours of mathematics, including 9 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. Two options are open for specialization, dependent on background, ability, and interests: systems, the integration of machine and human capabilities and techniques; and logico-mathematical, theoretical and systematic consideration of information systems and processes.

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 in these fields, and offers opportunities for well-qualified students to participate in sponsored research 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. The focus of development is the LEADERMART project, providing a fully computerized, on-line, conversational information system as a service of the Mart Library to Lehigh's interdisciplinary research centers.

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 admisssion 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.

110. (Math. 110) Algorithmic Reasoning (3)
The role of machines as physical models of abstract processes. Computability, practical computability, and unsolvability. Examples drawn from pure mathematics and will include recursive function theory and the real number system. Prerequisite: Math. 23 or Math. 32.

201. Computers and Language (3)
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)
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. Fields of Language Study (3)
A general survey of the major fields of language study: descriptive and historical linguistics, psycholinguistics, sociolinguistics, computer applications, statistical linguistics, stylistics.

301. Descriptive Linguistics (3)
Techniques for the description of the phonology, morphology, and syntax of natural languages. Special attention to transformational generative grammar.

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. Prerequisite: I.S. 301.

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.

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.

350. Applications of Non-Numerical Automata (3)
An introduction to basic automata and their application to non-numerical processes. Particular emphasis is given to uses involving artificial languages, simple natural languages, and basic symbol strings. The course will include a study of elementary automata theory; string processing compilers; automated simple grammars; and information retrieval aspects. Small computer programs will be written by the students, incorporating the theoretical concepts. Prerequisite: Math. 105 or equivalent.

361. (Math. 361) Theory of Formal Grammars (3)
The study of the structure of formal languages as determined by their formation-rule grammars. Comparison of grammars of differing strengths (finite—state, context-free, context-sensitive, etc.); considerations of applications in logic (Turing machines, decidability) and in linguistic (phase-structure and transformational grammars).

362. (Math. 362) Computer Languages (3)
For description see Math. 362.

373. Mathematical Methods in Information Science (3)
A general consideration of the role of mathematical techniques in information science, and a study of specific mathematical structures with applications in information retrieval theory.

374. Information Retrieval Theory (3)
An introduction to the problems of theory-construction for computerized information storage and retrieval systems. Special attention is given to the logical and mathematical foundations of automatic text-processing, file generation for retrieval, and inquiry negotiation.

379. Introduction to Library Organization (3)
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)
A study of methods and procedures in the application of automated equipment in libraries. Special attention is given to the augmentation of acquisition, cataloguing, circulations and reference functions. Prerequisite: I.S. 379 or consent of instructor.

390. Special Topics (1-3)
An opportunity for advanced work through supervised reading and research. Prerequisite: consent of instructor. Offered as required. 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)
Selected topics in linguistics not covered in other courses. (Offered as required.)

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.

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.

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.

433. (E.E. 403) Design of Executive Systems (3)
For description see E.E. 403.

434. Document Retrieval Evaluation (3)
Evaluation of systems and techniques for subject document retrieval. Fundamental ideas, achievements to date, problems and possibilities. Topics covered include evaluation of operation systems, experimental testing of retrieval techniques, uses of evaluation results, relation of "information needs and uses" studies, various evaluation measures, and the notion of "relevance." Prerequisite: I.S. 431 or equivalent.

442. Evaluation Models (3)
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)
Applications of graph theory to the modeling, simulation, and design of information networks. Prerequisite: I.S. 374. Offered as required.

462. Retrieval Languages (3)
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.

464. Mathematical Models in Linguistics (3)
Discussion of the goal and function of models in linguistics and of various criteria of adequacy for such models. Development and comparison of relational, algebraic, categorical, and other mathematical models for description of linguistic structure. Prerequisite: I.S. 361.

475. Retrieval Structures (3)
Advanced study of the application of mathematics and logic to the problems of retrieval system design and implementation, with particular emphasis on large-scale computer-based information networks. Prerequisite: I.S. 374 or consent of chairman of department.

480. Sentence Syntax (3)
Survey of various linguistic approaches to the analysis of sentences; co-occurrence, immediate constituents, phrase structure, kernels, transformations, and discourse considerations. Relevance of the material to language data processing will be considered. Prerequisite: I.S. 301.

481. Thesis (3)

482. Thesis (3)

492. Special Topics in Information Science (3)
Selected topics in the information sciences not covered in other courses. Offered as required.

Physics

Professors

James Alan McLennan, Ph.D., *Chairman*
Raymond Jay Emrich, Ph.D.
Robert Thomas Folk, Ph.D.
Wyman Beall Fowler, Ph.D.
Wesley Richard Smith, Ph.D.
Wilbur Devilla Bernhardt Spatz, Ph.D.
Wesley Johnson VanSciver, Ph.D.

Associate Professors

Brent W. Benson, Ph.D.
Garold J. Borse, Ph.D.
Frank J. Feigl, Ph.D.
Alvin S. Kanofsky, Ph.D.
Shelden H. Radin, Ph.D.
Russell A. Shaffer, Ph.D.
Donald B. Wheeler, Jr., Ph.D.

Assistant Professors

Ernest E. Bergmann, Ph.D.
Colin E. Jones, Ph.D.
Yong Wook Kim, Ph.D.

Students in the College of Engineering or the College of Arts and Science may major in physics leading to the B.S. or B.A. degree respectively. With the exception of the college requirements, for example the language requirement of the College of Arts and Science, the curricula are similar.

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 192	Advanced Laboratory (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 (6)

Major in College of Engineering

Freshman Year *(See page 45)*

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 (15-17 credit hours)

Phys 31	Introduction to Quantum Mechanics (3)
Phys 90	Electrical Phenomena (1)
Math 205	Linear Methods (3)
Eco 1	Economics (4)
	Electives (4-6)

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 (15-18 credit hours)

Phys 171	Proseminar (1)
	G.S. Requirement (3)
	Electives (11-14)

Notes: The lower number of credit hours represents the load required to meet the graduation requirement; the higher represents the normal semester load.

The electives must include at least 14 hours of approved technical electives, including two of Physics 363, 364, 365, 366, 367, and 369.

The required courses in the physics curricula include the minimum mathematical and subject matter requirements for entrance into graduate schools.* The intent of the program is to prepare students for careers in scientific work, either in physics or in some other science. Usually this involves continued study at the post-graduate level; however, many students who have terminated their formal education with the B.A. or B.S. in physics have found that it has been an excellent preparation for non-technical activities, as well as for science or innovative engineering.

The first two years of both programs are similar to most of the engineering curricula. The exception is Physics 31, which provides the student with an introduction to quantum mechanics before he begins the intensive intermediate level sequences. However, Physics 31 is not a prerequisite for the junior level course. A strong student in one of the engineering or science curricula could therefore transfer into physics as late as the beginning of the junior year with relatively little difficulty.

A liberal number of electives provides flexibility in allowing the curriculum to be adapted to the needs and interests of the individual student. Those whose interests lie in the theoretical or analytical aspects, or who are preparing for graduate study in physics, elect additional courses in mathematics and physics. Those who are interested in some 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 scientific 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)

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)
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.

12. Introductory Physics Laboratory I (1)
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)
Introduction to electricity and magnetism, waves, optics, and atomic physics, intended for students in the colleges of Arts and Science and of Business and Economics. Prerequisites: Phys. 11 and Math. 21, 31, or 41.

14. General Physics Laboratory (1)
A laboratory to accompany Physics 13. Prerequisites: Phys. 12; Phys. 13 preferably concurrently.

21. Introductory Physics II (4)
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.

*Students are to be forewarned that admission to graduate schools requires a minimum grade average. The level depends on the particular graduate school, but a typical minimum is approximately a "B" average. Also, many graduate schools require a reading knowledge of a modern foreign language.

22. Introductory Physics Laboratory II (1)
A laboratory course to be taken concurrently with Physics 21. One three hour laboratory period per week. Prerequisite: Physics 12.

31. Introduction to Quantum Mechanics (3)
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. 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. Prerequisite: Phys. 21. One three-hour laboratory period per week.

90. Electrical Phenomena (1)
Laboratory studies of elementary electric and magnetic effects. Elementary laboratory techniques. Prerequisite: Phys. 21, 22 or 13, 14.

171. Physics Proseminar (1)
Discussion of current problems in physics. Intended for seniors majoring in the field.

191. Laboratory Techniques (2)
Thermometric, calorimetric and vacuum techniques. Advanced electrical measurements. Prerequisite: Phys. 21, 22 or 13, 14.

192. Advanced Physics Laboratory (1-2)
Laboratory experiments in modern physics designed to introduce students to measuring techniques and phenomena of current interest. Work is of a project nature, and the student is placed largely on his own initiative. Intended for seniors majoring in the field.

193. Advanced Physics Laboratory (1-2)
Continuation of Phys. 192. Intended for seniors majoring in the field.

For Advanced Undergraduates and Graduates

212. Electricity and Magnetism I (3)
Electrostatics, magnetostatics, and electromagnetic induction. Prerequisites: Phys. 21 or 13; and Math. 205 previously or concurrently.

213. Electricity and Magnetism II (3)
Maxwell's equations; electromagnetic waves with applications to optics. Prerequisite: Phys. 212.

215. Particles and Fields I (3)
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.

216. Particles and Fields II (3)
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.

252. Optics (3)
Wave theory of light, interference, diffraction, polarization. Prerequisites: Math. 23 and Phys. 21 or 13.

254. Optics Laboratory (2)
Optical instruments and techniques. Examination of phenomena, of measuring procedures, and of light sources and recording devices. Prerequisite: Phys. 21 or 13.

266. Modern Physics (3)
General foundations of quantum theory, special theory of relativity, atomic theory of origin of spectra, wave mechanics, atomic and nuclear structure, interaction of particles with matter, radioactivity, nuclear structure. Intended for non-physics majors. Prerequisites: Math. 205, and Phys. 21 or 13.

281. Basic Physics I (3)
A course designed especially for secondary school teachers in the master teacher program. Presupposing a background of two semesters of college mathematics through differential and integral calculus and of two semesters of college physics, the principles of physics are presented with emphasis on their fundamental nature rather than on their applications. Open only to secondary school teachers and those planning to undertake teaching of secondary school physics.

282. Basic Physics II (3)
Continuation of Phys. 281.

300. Apprentice Teaching in Physics ——— (1-3)

340. Heat, Thermodynamics and Pyrometry (3)
Basic principles of heat, thermodynamics and kinetic theory of gases with emphasis on physical systems. Prerequisites: Phys. 21 or 13 and Math. 23, 32 or 44.

362. Atomic and Molecular Structure (3)
Structure of atoms and molecules, especially as related to their spectra. Prerequisite: Phys. 31 or Chem. 191.

363. Physics of Solids (3)
Introduction to the theory of solids with particular reference to the physics of metals. Prerequisite: Phys. 362, or Met. 361, or consent of chairman of department.

364. Nuclear Physics (3)
Properties of stable and unstable nuclei and experimental methods of measuring them; radioactive decay; detectors of nuclear radiation; types of nuclear reaction and methods of producing them; cosmic rays. Prerequisite: Phys. 369.

365. Physics of Fluids (3)
Basic concepts of classical fluid mechanics; continuum and molecular approaches; shock waves; high temperature properties of reacting ideal gases; plasma dynamics. Prerequisites: Phys. 213 and 340.

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.

367. Introduction to Molecular Biophysics (3)
A development of the molecular basis of life in terms of physical principles, including applications of selected physical techniques to problems in molecular biology. Prerequisites: Phys. 21 or 13.

369. Introduction to Quantum Mechanics (3)
Principles of quantum mechanics; applications to atoms and molecules. Prerequisites: Phys. 31, 216, Math. 205.

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 strengths 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 chairman of the department. 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 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.

Graduate Courses

420. Theoretical Physics (3)
This and the three courses, Phys. 421, 422, and 423, cover the classical theory of particles and fields. Physics 420 includes the variational methods of classical methanics, methods of Hamilton and Lagrange, canonical transformations, Hamilton-Jacobi theory.

421. Theoretical Physics (3)
Theory of elasticity; fluid dynamics; tensor analysis; electrostatics and magnetostatics. Prerequisite: Phys. 420.

422. Advanced Theoretical Physics (3)
Electromagnetic radiation; dynamics of charged particles; multipole fields; special theory of relativity and covariant formulation of electrodynamics. Prerequisite: Phys. 421.

423. Advanced Theoretical Physics (3)
Electrodynamics in anisotropic media; physical optics; theory of diffraction and application to holography; applications of electrodynamics in various fields of physics. Prerequisite: Phys. 422.

424. Quantum Mechanics (3)
General principles of quantum theory; approximation methods; spectra; symmetry laws; theory of scattering. Prerequisite: Phys. 369 or equivalent.

425. Quantum Mechanics (3)
A continuation of Phys. 424. Relativistic quantum theory of the electron; theory of radiation.

428. Methods of Mathematical Physics (3)
The equations of theoretical physics and the methods of their solution.

429. Methods of Mathematical Physics (3)
Continuation of Phys. 428.

431. Theory of Solids (3)
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.

434. Solids and Radiation (3)
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)
General principles of statistical mechanics with application to thermodynamics and the equilibrium properties of matter. Prerequisites: Phys. 340 and 369.

443. Statistical Mechanics (3)
A continuation of Phys. 442. Applications of kinetic theory and statistical mechanics to non-equilibrium processes; non-equilibrium thermodynamics. Prerequisite: Phys. 442.

462. Theories of Elementary Particle Interactions (3)
Relativistic quantum theory with applications to the strong, electromagnetic and weak interactions of elementary particles. Prerequisite: Physics 425.

465. Nuclear and Elementary Particle Physics (3)
Nuclear structure and phenomena; interactions among elementary particles and methods of studying them.

467. Nuclear Theory (3)
Theory of low energy nuclear phenomena within the framework of non-relativistic quantum mechanics.

471. (Mech. 411) Continuum Mechanics (1-3)
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.

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

Martin L. Richter, Ph.D.
George K. Shortess, Ph.D.
Sidney I. Stecher, Ph.D.

Assistant Professors

Edwin J. Kay, Ph.D.
Roger C. Loeb, Ph.D.
Donald A. Mankin, Ph.D.
William Newman, Ph.D.

Adjunct Professors

Herbert Rubenstein, Ph.D.
Mervin P. Smolinsky, Ph.D.

There are two major programs available in psychology. The B.A. 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 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 psychology (either experimental or clinical) or medicine or dentistry. Students in the B.A. program who decide to pursue graduate study are encouraged to use the B.S. program as a guide in the selection of courses.

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.

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 11	General Experimental Psychology (4)
Psych 51	Elementary Quantitative 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 361	Theory of Formal Grammars (3)

or other courses with the approval of the chairman of the department. (It is recommended that these 12 semester hours

be concentrated in an area, e.g., mathematics, probability and statistics, biology, biochemistry, computer science.

Plus 42 semester hours of electives. (46 semester hours if Math. 31 and 32 are taken.)

Undergraduate Courses

3. Psychology as a Natural Science (3)
Introduction to psychology as a science of behavior. Emphasis on principles of sensation, perception, maturation, learning, motivation, emotion and physiological bases of behavior.

4. Psychology as a Social Science (3)
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.

9. Statistical Analysis (3)
An integrated presentation of the basic methods of evaluating data in psychological research.

11. General Experimental Psychology (4)
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.

21. (S.R. 21) Social Psychology (3)
For description, see S.R. 21.

51. Elementary Quantitative Psychology (3)
Quantitative analysis of behavior, including perception, choice and preference, conditioning, memory, and problem-solving.

101. Psychological Tests and Measures (3)
Psychological tests of intelligence and personality with principles of measurement and test construction emphasized.

107. Developmental Psychology (3)
Theories and research dealing with the development of the human organism. The course of development will be traced from fetus to adolescent. Prerequisite: Psych. 3 or 4.

121. Encountering Self and Others (3)
An experientially-oriented course to facilitate personal growth and develop a fuller awareness of personal functioning and interpersonal perception and communication. Prerequisite: consent of instructor.

160. Independent Study (1-3)
Readings on topics selected in consultation with a staff member. Prerequisites: Psych. 3 or 4 and consent of chairman of department. May be repeated for credit.

161. Independent Research (1-3)
Research in areas selected in consultation with a staff member. Prerequisites: Psych. 3 or 4, 11, and consent of chairman of department. May be repeated for credit.

162. Psychological Field Work (3)
Work-study practice including supervised experience in one of several local agencies. Development of familiarity with the operations of the agency and working with individual patients or students. Prerequisites: Psych. 3 or 4 and consent of instructor. May be repeated for credit.

For Advanced Undergraduates and Graduates

201. Industrial Psychology (3)
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.

251. Psychological Perspectives in Technological Society (3)
The relationship between technology and the problems of society with emphasis on the social and psychological environment. Includes problems of work and leisure, values in post-industrial society, futuristics, and implications of technological decisions. Prerequisite: Psych. 3 or 4.

300. Apprentice Teaching in Psychology ——— (1-3)

301. Psychological Principles in Systems Design (3)
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)
The application of mathematics in psychology, including models for psychophysics, learning acquisition curves, discrimination learning, concept formation and probability learning. Prerequisite: Psych. 11.

306. Psychopathology (3)
Theories of abnormal behavior and its development. Systematic analysis of psychopathological syndromes and their remediation. Lectures supplemented by observations at the Allentown State Hospital. Prerequisites: Psych. 3 or 4, and 6 additional credit hours of psychology.

307. Perception-Cognition (3)
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.

311. History of Modern Psychology (3)
History of psychology, with emphasis on the emergence and growth of scientific study of behavior. Includes the readings of primary sources and the autobiographies of the major contributors to the field. Prerequisite: Psych. 3 or 4.

320. (I.S. 302) Psycholinguistics (3)
For course description, see I.S. 302.

331. Humanistic Psychology (3)
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.

361. Personality (3)
Survey of basic theoretical and research techniques used to conceptualize and assess personality. Includes analytic and learning theory and such methods as interviewing, rating scales, intelligence tests and projective tests. Prerequisites: Psych. 3 or 4, and 3 additional credit hours in psychology.

371. Learning (3)
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.

372. Learning Laboratory (1)
Experimentation on the learning process utilizing animal and human subjects. Prerequisites: Psych. 11; Psych. 371, previously or concurrently.

373. Sensory Processes (3)
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.

374. Sensory Processes Laboratory (1)
Laboratory exercises applying quantitative methods to the study of sensory processes. Prerequisites: Psych. 11; Psych. 373, previously or concurrently.

375. Physiological Psychology (3)
The physiological basis of behavior, both human and animal. Particular emphasis is placed on the neural mechanisms involved. Prerequisites: Psych. 3 or 4; 8 semester hours of physics, chemistry or biology.

376. Physiological Psychology Laboratory (1)
A survey of techniques in physiological psychology. Prerequisite: Psych. 375 previously or concurrently.

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 chairman of department. Open only to graduate students in the School of Education.

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 chairman of department. Open only to graduate students in the School of Education.

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 the chairman of the department. Open only to graduate students in the School of Education.

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. The Ph.D. program is in experimental psychology with major concentration in the area of learning or visual science. Additional opportunities for interdisciplinary work exist in quantitative methods, engineering psychology, and psycholinguistics. The D. A. program is designed as preparation for a career in college teaching of experimental psychology at two-year and four-year colleges.

The beginning student is required to take (1) Proseminar, an intensive one-semester course covering topics in experimental psychology, (2) Analysis and Design of Experiments, a two-semester course in probability, statistics, and research methodology, and (3) Research, an apprentice program in which the student works with a faculty member on a current research project. A required master's thesis may evolve from the apprentice research. 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. (A student coming to the department with a master's degree is permitted to take the examinations without taking these courses.) Evaluation is also based on progress in research and performance in other courses.

Each student's program is tailored to his 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.

The Ph.D. specialization in learning consists of investigation of both human and animal learning. The facilities for research include housing for different experimental animals, electrical and woodworking shops, experimental cubicles, electromechanical and solid state programming and recording equipment, desk calculators and a University computer. Current ongoing research in the department includes animal alternation learning, human information integration, and human discrimination learning.

The Ph.D. specialization in visual science integrates the physical science and engineering approach with that of the life and behavioral sciences for a better understanding of human visual interaction with the environment. Areas of concern include neuroanatomical, neurophysiological and psychophysical studies of vision, optics and the nature of the visual stimulus, modern instrumentation and research techniques, and current theory and data of the visual system.

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. Training in interpersonal awareness is intended to break down the barriers which inhibit direct and genuine communication between student and teacher. The research project may deal with innovative approaches to curriculum preparation and presentation such as course structure, curriculum materials, development of new educational technologies, and novel means of communicating psychological concepts. Teaching experience includes service as a supervised teaching assistant in courses offered at Lehigh University and a supervised teaching internship outside Lehigh University.

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 G.R.E. 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 (6)
Intensive examination of the classic work and current issues in a variety of areas of experimental psychology.

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 instructor. May be repeated for credit.

421. Analysis and Design of Experiments (3)
Set theory, probability theory, inferential statistics, parametric and non-parametric statistical tests with emphasis on the analysis of variance, curve-fitting, trend analysis, regression analysis.

422. Analysis and Design of Experiments (3)
Continuation of Psych. 421. Emphasis on experimental design. Prerequisite: Psych. 421.

423. Seminar in Statistical Methods (3)
Selected topics in statistics applied to psychological research. May be repeated for credit.

428. Thesis (3)
Original investigation for the master's thesis.

429. Thesis (3)
Continuation of Psych. 428.

432. Perception (3)
Evaluation of contemporary research and theories of human perception.

433. Conditioning and Learning (3)
Coverage of a variety of empirically investigated topics and theories in learning.

434. Personality (3)
Traditional theories of personality will be reexamined in light of current research, particularly in the fields of learning and neurophysiology.

436. Physiological Psychology (3)
A detailed review of the physiological basis of behavior with particular emphasis on infrahuman vertebrate neural systems. Prerequisite: Psych. 365.

438. History of Psychology (3)
Interpretation of selected works of authors who have contributed significantly to the growth of scientific psychology.

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 instructor.

448. (I.S. 402) Seminar in Psycholinguistics (3)
For course description, see I.S. 402.

450. Special Topics in Mathematical Models (3)
Selected topics from stimulus sampling theory; game and decision theory, continuous response models, models of memory. May be repeated for credit.

451. Vision (3)
A systematic study of the methods and chief results in the study of visual processes.

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.

455. Topics in Engineering Psychology (3)
Application of experimental psychology to man-machine systems, e.g., sensory load and performance; perception and motion; man-computer interaction; system development; psychophysiology of human performance. May be repeated for credit.

460. Special Study (1-3)
Study of some special topic not covered in the regular course offerings.

461. Research (1-3)
Original research not connected with master's or doctoral thesis.

463. College Teaching of Psychology (1-3)
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.

465. Teaching Internship (3-6)
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, etc. Prerequisite: Psych. 365. May be repeated for credit.

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.

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.

478. Special Topics in Information Processing (3)
A topic in human information processing with problems drawn from the areas of perception, memory, and learning, e.g., short-term memory, selective attention, pattern perception, perceptual learning. May be repeated for credit.

Religion Studies

Professor

A. Roy Eckardt, Ph.D., *Chairman*

Assistant Professor

Hubert L. Flesher, M.A.

Instructor

Patricia M. Lyons, M.A.

Lecturer

Alice L. Eckardt, M.A.

As an intrinsic dimension of man's culture, religion exerts abiding influence upon human thought and behavior. This fact comprises the rationale for the study of religion at Lehigh University. The department of religion studies is committed to forms of intellectuality identical with those pursued in other humanistic and scientific disciplines. Our purpose is to help complete and sustain a student's liberal education. In addition, the scholarly analysis of religion comprises one foundation for a mature personal and social faith.

Courses in the department afford a comprehensive understanding of the world's major religious traditions and their contributions to human culture. The curriculum extends through the methodology of religion study, the history of religions ("comparative religion") in East and West, biblical studies, influential theological movements and issues, and the relating of religion to contemporary moral and social questions.

When this catalog went to press, Lehigh University was in the process of implementing a major program in religion studies. Students interested in such a major are advised to consult with the chairman of the department.

Undergraduate Courses

15. Methods and Issues (3)
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.

51. Faiths of the Orient (3)
The rise, development, and teachings of Hinduism, types of Buddhism, and several lesser-known religions of India.

52. Faiths of the West (3)
The rise, development, and teachings of Judaism, Christianity, and Islam.

111. Biblical Studies I (3)
Theological examination of the Old Testament writings, with emphasis upon literary-historical and critical problems. The Exodus tradition and the Patriarchal Period; the conquest of the Land; the development and dissolution of the Monarchy; the Prophetic Movement; the Post-Exilic Period; the Law; and the Temple and its related culture.

112. Biblical Studies II (3)
Literary-critical and theological study of New Testament writings, with emphasis on the four Gospels, Acts, and the major Epistles. The life and teachings of Jesus and of Paul. The theological viewpoint of the New Testament church.

151. The Jewish-Christian Encounter (3)
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. American Religions (3)
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.

161. Current Issues in Theology I (3)
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)
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

213. Conflict and Conscience I (3)
The relating of religio-ethical principles to major moral and social issues of today, with the aid of influential contemporary theologians and movements. Emphasis upon competing political, social, and economic systems, revolution, international conflict, and the rule of law.

214. Conflicts and Conscience II (3)
Continuation of Religion Studies 213 (which is not a prerequisite). Religious and racial prejudice, ecology, medical-genetic-eugenic ethics, sex and marriage, and vocational decision-making.

261. Seminar in World Religions (3)
In-depth study of selected topics within Hinduism, Buddhism, African religions, or other world religions.

272. Religion and the Arts (3)
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)

302. Seminar in Technology and Religious Thought (3)
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)
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)
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)
Continuation of Religion Studies 371. Prerequisite: consent of department chairman.

Reserve Officers' Training Corps

Lehigh University offers two voluntary Reserve Officers' Training Corps programs in cooperation with the United States Government: the department of military science offers preparation for a commission in the U.S. Army while the department of aerospace studies prepares individuals for commissioning in the U.S. Air Force.

The general objective of both the Army and Air Force programs 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.

Army and Air Force ROTC course credits may be substituted for six hours of electives for those students in the College of Arts and Science and the College of Business and Economics. Students in the College of Engineering may substitute advanced ROTC credits for six hours of elective general study courses.

Both departments are basically organized around four- and two-year programs and offer financial assistance to qualified students in the form of four-, three-, two-, and one-year scholarships and/or monthly tax-free subsistence allowances.

Department of Military Science

Professor

Lieutenant Colonel Benjamin L. Abramowitz, M.B.A., *Chairman*

Associate Professor

Major Donald H. Kunkel, B.S.

Assistant Professors

Captain Joseph F. Dannenfelser, B.S.
Captain John S. Ellison, B.S.
Captain Stephen A. Schmidt, B.A.

Instructors

SSG Edward G. Becker
SGM Joseph Kress
SGM Walter Malich

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 an ROTC program since September 1919. Currently, Army ROTC offers a four-year program and a two-year program. The four-year program consists of a two-year Basic Course and a two-year Advanced Course, 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 who would otherwise be eligible for enrollment in the Basic Course but who did not take ROTC during their first two years of college 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. Pay for the summer training is at the rate of $307.20 per month plus transportation costs to and from this camp.

Advanced Courses. 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 $100.00 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 $283.05 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 these courses are supplied by the department. A cash deposit of $25 is required of all students at the time of registration. This deposit is returned upon his return of all issued property.

ROTC Scholarship Program. The ROTC scholarship program is designed to offer financial assistance to outstanding young men 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 $100.00 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 the Army Headquarters serving their state of residence during the senior year of high school, normally before 15 January. 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 prior to the Advanced Course summer camp, approximately one-third of each junior ROTC class may be designated as potential Distinguished Military Students (DMS). A student who maintains the same high standards throughout summer camp and his 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 extra-curricular activity conducted by an approved FAA flying school near the University. The instruction consists of 35 hours of ground training and more than 36 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. A qualified student transferring from another institution may enter the ROTC program at the appropriate advanced level and year, providing he has received the necessary credits, the recommendation of his former professor of military science, and the approval of this 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 four years in a Reserve status. Depending on Army requirements, a 3-6 month active duty for training with an 8-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 at least 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 an ROTC graduate may delay his 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 colleges of Arts and Science and of Business and Economics may substitute advanced

military science credits for six hours of electives. Students in the College of Engineering may substitute advanced military science for six hours of general study (elective) courses. The 2 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 overall cumulative academic average.

Basic Course

13. Basic Military Science (1)
This introductory course examines the purpose, history and organization of ROTC, the Army and the Department of Defense, and the evolution of military weapons with stress placed on present-day weapons and their functioning. The course consists of one recitation period and two hours of leadership laboratory per week.

14. Basic Military Science (1)
This course examines the organization of 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.

21. Basic Military Science (2)
This course presents map and aerial photography, to include use of the compass, an introduction to military tactics and operations, 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)
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)
This course examines the systems, principles and techniques of military communications, 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)
This course examines the leader's role in directing and coordinating small tactical units in the execution of offensive and defensive operations, the roles, missions and job opportunities of the various branches of the Army, and the psychological, physiological, and sociological factors which affect human behavior with individual and group solutions of case studies of leadership 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 professor of military science, 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 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."

107. Advanced Military Science (2)
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)
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, problems, 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)
Enrollment limited to two 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 positions 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 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. One four-hour leadership laboratory will be conducted on a Saturday morning during each of the semesters. Attendance at these sessions will eliminate the requirement for at least the equivalent number of the regular two-hour weekly sessions during the winter months.

Department of Aerospace Studies

Professor

Colonel William F. Shimonkevitz, M.S., *Chairman*

Assistant Professors

Major Richard C. Brace, M.S.
Captain Delford G. Britton, M.A.
Captain John A. Fratto, M.B.A.

Assistants

Master Sergeant Carl L. Young, Jr.
Staff Sergeant Jesse F. Marsh
Staff Sergeant David J. Adkins
Staff Sergeant Gregory B. Wilson

Air Force ROTC at Lehigh University was established in October 1946. The department of aerospace studies offers two 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 his 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 28th birthday.

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 throughout the activation of the scholarship.

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 36½ hours of flying time, 35 hours of instruction (20 hours dual and 15 hours solo), plus 1½ hours for a final flight progress check. Cadets who complete the 35 hours of instruction, and pass the FAA written examination and the final flight check, may receive an FAA private pilot's license.

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's 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 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 $460.00, and those in the four-week course receive $566.00. 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)
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.

22. Freshman Aerospace Studies (1)
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.

23. Sophomore Aerospace Studies (1)
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.

24. Sophomore Aerospace Studies (1)
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 air power on strategic thought.

111. Aerospace Studies—Air Force Officer Development (3)
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.

112. Aerospace Studies—Air Force Officer Development (3)
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.

113. Aerospace Studies—The Professional Officer (3)
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.

114. Aerospace Studies—The Professional Officer (3)
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.

Social Relations

Professors

Robert Clifford Williamson, Ph.D., *Chairman*
Morris H. Sunshine, Ph.D.

Associate Professor

Roy Cecil Herrenkohl, Jr., Ph.D.

Assistant Professors

James Rathburn McIntosh, Ph.D.
Robert E. Rosenwein, Ph.D.

Instructor

Barbara Brown Frankel, M.A.

Visiting Instructor

Philip W. Marden, Ph.D.

There are three major sequences combined in the department of social relations: social psychology, sociology, and anthropology—behavioral sciences. Students majoring in the department usually select one option to fulfill requirements.

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 his major program.

Required Preliminary Courses

SR 292	Research Methods (4)

Two of the following:

SR 11	Principles of Sociology (3)
SR 21	Social Psychology (3)
SR 31	Introduction to Anthropology (3)

(One course must be in the major option of the student.)

Option in Social Psychology

One of the following:

SR 201	Social Psychology of Education (3)
SR 203	Social Ecology (3)

Two of the following:

SR 303	The Social Psychology of Groups (3)
SR 304	Human Communication (3)
SR 305	Personality and Social Processes (3)
SR 307	Attitudes and Social Influence (3)
SR 309	Socialization Through the Life Span (3)

One of the following in the senior year:

SR 308	Seminar on Social Psychology (3)
SR 394	Individual, Society and Culture (3)
SR	One 300-level course in either sociology or anthropology (3)
Psych	One approved course (3)

Option in Sociology

Five of the following:

SR 360	Social Change in Africa (3)
SR 364	The Family (3)
SR 366	Population Problems (3)
SR 367	Latin American Social Institutions (3)
SR 368	The Urban Community (3)
SR 369	Social Disorganization (3)
SR 370	Juvenile Delinquency (3)
SR 373	Seminar in Sociology (3)
SR 374	Social Stratification (3)
SR 381	Development of Sociological Theory (3)
SR 382	Political Sociology (3)
SR 383	Industrial Sociology (3)
SR 384	Social Structure (3)
SR	300-level courses in anthropology or social psychology (6)

Minor in Anthropology-Behavioral Sciences

Eighteen hours of which at least twelve will be chosen from S.R. 332, 335, 336, 339, 341, 343, 394, and I.S. 301. The remainder will be selected with the approval of the departmental advisor.

Undergraduate Courses

3. Introduction to Social Relations (3)
An interdisciplinary study of man's evolution, culture, society and individuality. Social psychological, anthropological and sociological materials will be discussed to explore the contrasting definitions of man developed in contemporary social science.

4. Introduction to Social Relations (3)
A continuation of S.R. 3 with attention placed on man's participation in the social process and theories of social change. Cross-cultural investigations and research into contemporary issues in American society will be studied to examine how the individual is affected by and affects his social environment.

11. Principles of Sociology (3)
An introduction to the field of sociology and its concepts and methods. Among the topics are the nature of the group, social organizations and structure, socialization, stratification, social institutions, ethnic relations, social change.

21. (Psych. 21) Social Psychology (3)
An introduction to the theories, methods of investigation, and research results of social psychology with emphasis on psychological processes in social behavior, social attitudes, group behavior and social interaction.

31. Introduction to Anthropology (3)
Examination of the scope, aims and methods of anthropology. The nature of culture, cultural-biological relationships, human evolution, archaeology and cultural evolution, language and cultures, cultural phenomena with emphasis on economic organization, kinship and social organization, religion and political organization. Analysis of the characteristic features of life, thought and culture of selected non-Western peoples.

41. Human Sexuality (3)
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.

65. Contemporary Social Problems (3)
An exploration of major problems facing contemporary man, the social contexts giving rise to these problems, and the social consequences of alternative strategies for dealing with them. Selected problems such as mental health, crime, the population explosion, racial tensions, the modern city, and war will be studied in detail.

75. Minority Groups (3)
Ethnic minorities and intergroup relations. Consideration of the historical and social character of minority groups and an examination of theory and research focusing on intergroup cooperation and conflict.

101-102. Social Research in the Field Setting (3 or 4)
Independent study of community problems by participation in community efforts to solve them. Students will conduct research or a relevant project under faculty supervision. Prerequisite: consent of instructor.

For Advanced Undergraduates and Graduates

201. 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.

203. Social Ecology (3)
An examination of the manner in which the physical environment and the organization of society interacting with individual needs shape human behavior. Consideration of factors such as technology, architectural design, environmental awareness, the need for privacy and interpersonal space.

231. Non-Western People (3)
An introduction to the variety of man's social life. A number of tribal and peasant societies are examined in relation to their social and technological complexity. Emphasis is placed on whole societies rather than societal mechanisms. Attention is also given to man's relationship to the physical environment and the degree to which cultural change is influenced by extra-cultural factors.

292. Research Methods (4)
Training in the methods of research used in the study of social relations. Study of selected problems and applications in research design, execution, analysis, and interpretation. Introduction to major techniques of research including laboratory experimentation, field study, and participant observation; questionnaire construction and interview procedure. Introduction to different levels of analysis. Prerequisite: six credit hours in social relations or consent of chairman of department.

303. Groups and Organizations (3)
Survey of theories and empirical research on interpersonal behavior in groups and organizations. Emphasis on such topics as: structure and process, group size, communication networks, leadership, power, decision-making and effectiveness. Prerequisite: six credit hours in social relations or consent of chairman of department.

304. Human Communication (3)
Problems in understanding the processes and functions of communicative behavior. Analysis of speech and language theories of communication, and the effects of communication in groups. Prerequisite: one course in social relations or equivalent.

305. Personality and Social Processes (3)
An examination of the relationship between personality and social behavior. Topics include small-group behavior, personal attraction, competition, cooperation, and communication. Prerequisite: S.R. 21.

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. 21.

308. 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. 21 or consent of chairman of department. May be repeated for credit.

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. 21.

320. (U.S. 320) Urban Ethnology (3)
Ethnocultural groups in urban settings. Patterns of conflict, accommodation and assimilation studied with particular reference to the United States.

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.

332. Peasant Societies (3)
Analysis of peasants as members of transitional societies; relationships between peasant groups and larger political entities. Examination of peasant cultures in their economic, social, and structural similarities. Intensive treatment of ethnographies of peasant societies. Prerequisite: S.R. 31 or consent of chairman of department.

335. Cultural Dynamics (3)
Critical evaluation of approaches to the problems of cultural change; analysis of invention and intergroup cultural borrowing; agents and conditions conducive to change; mechanics of culture growth; and applications of techniques for inducing change. Attention to the impact of Western civilization upon traditional native societies; socio-cultural adjustments to the impact; and community disintegration and reintegration.

336. Religion and Magic (3)
A comparative analysis of the origins, elements, forms and symbolism of religious beliefs and behavior; the role of religion in society with particular reference to nonliterate societies. Anthropological theories and methods of analysis of religion, both historical and contemporary, will be considered.

337. Anthropological Theory (3)
An examination of the theoretical foci of anthropology and its relation to disciplines, e.g., ecology, linguistics, ethnohistory, the cross-cultural study of cognition, etc.

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: six credit hours in social relations or consent of the chairman of department.

341. Comparative Institutions (3)
A cross-cultural examination of topics such as kinship, social institutions, politics, law, and economic organization. Types of systems and their functions; anthropological theory and methods of analysis. May be repeated for credit.

343. Area Studies (3)
Particular cultural-geographic areas examined from cultural, historical, environmental and linguistic perspectives. The relation of area research to anthropological theory. May be repeated for credit.

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.

364. The Family (3)
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.

366. Population Problems (3)
Quantitative and qualitative aspects of U.S. and world population. Includes: causes and effects of migrations, racial compositions and race relations, population theories, legal aspects, social consequences of population trends, present trends and future predictions.

367. Latin American Social Institutions (3)
An introduction to the contemporary indigenous, mestizo and creole cultures of Latin America with analysis of specific communities. An investigation of familial, educational, religious, and recreational institutions with particular emphasis on intellectual developments. Attention to the problem of change and social planning. Prerequisite: one course in social relations or consent of chairman of department.

368. The Urban Community (3)
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 chairman of department.

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 chairman of department.

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 chairman of department.

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 will vary from semester to semester. Prerequisite: six credit hours in social relations or consent of chairman of department. 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: six credit hours in social relations or consent of chairman of department.

381. Development of Sociological Theory (3)
A critical and comparative study of the principal schools of social thought which have contributed to the development of sociological theory. The origins and development of sociology, major contributors, current trends. Prerequisite: six credit hours in social relations or consent of chairman of department.

382. Political Sociology (3)
Organization and development of political action structures—movements, parties, systems—under varying societal conditions. Comparative analysis of ideology, stratification, leadership, and patterns of political participation.

383. Industrial Sociology (3)
Course and consequence of industrialization in different societal settings. The industrial plant as a composite and a component of local, regional and national structures of organization in transaction with other institutional areas.

384. 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: six credit hours in social relations or consent of chairman of department.

394. The Individual, Society and Culture (3)
This course will explore the interdisciplinary implications of the materials and methods of social psychology, sociology, and anthropology. Prerequisite: six credit hours in social relations or consent of chairman of department.

For Graduates

411. Advanced Research Methods (3)
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.

412. Practicum in Research Methods (3)
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.

432. Culture Patterns and Personality (3)
The psychological implications of cultural variation, including the analysis of national character.

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.

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.

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.

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.

470. Contemporary Sociological Theory (3)
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.

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.

Physical Education & Athletics

Professor

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

Assistant Professors

John Nelson Covert, B.S.
Frederick Homer Dunlap, B.A.
Leroy Arlan Heckman, M.A.
Gerald Grant Leeman, B.A.
Anthony Packer, B.S.
John Stohler Steckbeck, M.Sc.
B. Thayer Turner, B.S.

Instructors

Helen Bond, B.S.
Barry J. Fetterman, B.S.
Thomas M. Gilburg, B.A.
Lawrence D. Glueck, B.A.
Charles R. McNaron, B.S.
Stanley R. Schultz, B.A.
John Calvin Whitehead, B.S.
Thomas Pugliese, B.A.
Bruce Gardiner, M.Sc.

The division consists of the department of intercollegiate athletics and the department of physical education and intramural sports. It has supervision over the entire field of intercollegiate athletics and physical education at the University. Its activities consist of intercollegiate athletics, intramural athletics, and physical education, including corrective exercises.

Experience indicates that it is essential that the physical education program 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, physical education, 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 the undergraduate student 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 participation in vigorous competitive athletics.

Facilities for accomplishing these are afforded in Taylor Gymnasium, Grace Hall, Taylor Field, and Sayre Park field, an area of seven acres located above the lookout on the top of South Mountain and only a short distance from the fraternity houses and residence halls, and Saucon Valley Fields located south of the campus and on the south side of South Mountain. These 500 acres 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 which is the site of a future stadium. Almost all of the outdoor intramural sports contests and all upperclass intramural activities are held in this area; a shuttle bus service is provided to and from this field.

Department of Intercollegiate Athletics

The department of intercollegiate athletics offers opportunity to the undergraduate student body to participate in intercollegiate competition both at home and away with institutions which are Lehigh's natural 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, 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 of the University.

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 by-products 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 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 current health status.

The physical education program is voluntary, but all physically qualified students are required to take a swimming test and physical fitness test for the purpose of guidance and counseling in the voluntary program of personal development. Both tests are scheduled during the first week of the first semester. Based on the results of the tests, each student is urged to follow the recommendations of counselors in improving his physical condition.

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. Coed instruction and competition 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, beginner's 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 University 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

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.

Board of Trustees

Board of Trustees

Officers of the Board of Trustees

Monroe Jackson Rathbone, President (until 6/30/73)
Harold Scheaffer Mohler, President (after 7/1/73)
Elmer William Glick, Secretary and Treasurer
Paul Justus Franz, Jr., Assistant Secretary

Corporate Members

Monroe Jackson Rathbone, Ch.E. '21, Eng.D., Sc.D., LL.D.
Chairman of the Board (Retired)
Standard Oil Company (New Jersey)

Leonard Mead Horton, B.S. in Bus. Adm. '28, LL.D.
Chairman of the Board (Retired)
Aubrey G. Lanston & Company, Inc.

Edward A. Curtis, B.S. in Bus. Adm. '26, LL.B., LL.D.
Vice President for Public Affairs (Retired)
New Jersey Bell Telephone Company

Hugh Paul McFadden, B.A. '25, LL.B., LL.D.
Partner
McFadden, Riskin & Huston

Ivor Donald Sims, B.S. in Bus. Adm. '33, LL.D. '70
Executive Vice President (Retired)
Bethlehem Steel Corporation

Edwin Henry Snyder, E.E. '23, Eng.D. '68
Board Chairman & Chief Executive Officer (Retired)
New Jersey Public Service Electric & as Company

William Boal Eagleson, Jr., B.S. in Bus. Adm. '49, M.B.A. '51
President
Girard Bank

C. Lester Hogan, B.S., M.S., Ph.D., Hon. A.M., Eng.D., D.Sc., Eng.D. (Hon.)
President
Fairchild Camera and Instrument Corporation

Donald Billman Stabler, B.S. in C.E. '30, M.S.
President
Stabler Construction Company

Edwin Hays Gott, B.S. in I.E. '29, Eng.D. '68, Sc.D., LL.D.
Chairman of the Board (Retired)
United States Steel Corporation

Corporate Members Emeritii

Nevin Elwell Funk, E.E. '05, Eng.D.
Executive Vice President (Retired)
Philadelphia Electric Company

Frank William Sterrett, A.B., B.D., D.D., S.T.D., LL.D.
Bishop (Retired)
Episcopal Diocese of Bethlehem

Andrew Edward Buchanan, Jr., Ch.E. '18, Eng.D.
General Manager (Retired)
DuPont

Frank Lynn Magee, E.E. '17, Eng.D., LL.D.
Chairman of the Board (Retired)
Aluminum Company of America

Allen Corson Dubois, B.A. '25, LL.D.
Partner (Retired)
Wertheim & Company

Kenneth Lothaire Isaacs, M.E. '25, M.B.A., LL.D.
Chairman, Board of Trustees (Retired)
Massachusetts Investors Trust

Henry Randolph Maddox, M.E. '21
Vice President (Retired)
American Telephone and Telegraph Company

Members Elected by Alumni

(Number in parentheses indicates year term expires)

Frank Gregg Kear, E.E. '26, S.M., Sc.D. (1973)
Partner
Kear & Kennedy

John Dickson Harper, B.S. in Bus. Adm. '65, M.B.A. '67 (1973)
Chairman
Cinemette Corporation of America

Malcolm Carrington, Jr., B.S. in Bus. Adm. '39 (1974)
Vice President and Secretary
New Jersey Public Service Electric & Gas Company

Kirk P. Pendleton, B.S., B.A. '63 (1974)
Vice President
Pitcairn, Incorporated

The Rt. Rev. Dean T. Stevenson, B.A. '37, M.A. '49, S.T.B. '40, S.T.D., D.D. '69 (1975)
Bishop
Episcopal Diocese of Harrisburg

Alfred Greene Blake, C.E. '25 (1976)
Chairman of the Board
Engelhard Minerals & Chemicals Corporation

Harold Sheaffer Mohler, B.S. I.E. '48 (1977)
President
Hershey Foods Corporation

William C. Hittinger, B.S. in Met. E. '44 (1977)
Executive Vice President
Consumer & Solid State Electronics
Radio Corporation of America

Appointed Trustees

(Number in parentheses indicates year term expires)

Ralph Lawrence Wilson, El.Met. '21, L.H.D. '68 (1973)
Director of Metallurgy (Retired)
Timken Roller Bearing Company

William Frederic Colclough, B.A. '25, LL.B. (1974)
Chairman of the Board (Retired)
American Bank Note Company

Stirling Murray Rust, Jr., B.S. in M.E. '34 (1974)
Chairman of the Board (Retired)
Rust Engineering Company

Frank Cornelius Rabold, B.S. in E.E. '39, Eng.D. '70 (1975)
Manager of General Services
Bethlehem Steel Corporation

James Herron Walker, B.A. in Econ., M.B.A. (1975)
Vice President, Finance (Retired)
Bethlehem Steel Corporation

Leonard Parker Pool, Eng.D. '65, Sc.D., D.S.S. (1976)
Chairman and Chief Executive Officer
Air Products & Chemicals, Inc.

Frederick Seitz, A.B., Ph.D., LL.D. '66 (1976)
President
The Rockefeller University

Edmund Fible Martin, M.E., Eng.D., LL.D. '67 (1977)
Chairman of the Board and Chief Executive Officer (Retired)
Bethlehem Steel Corporation

Honorary Trustee

Leonard Jerome Buck, B.S. in E.M. '15
President (Retired)
Leonard J. Buck Company, Inc.

Departmental Visiting Committees

The University is eager to strengthen fruitful communication with the society which it serves, and that desire motivated the establishment of Visiting Committees of the Board of Trustees. These committees annually bring to the University representatives of industry, government, and education who study those areas of the University which they are most competent to judge, and report periodically on their evaluation of those areas. Members of the Board of Trustees often serve as chairman of the Visiting Committees.

Athletics

G. Douglas Reed
Vice President—Manufacturing
McCormick & Co., Baltimore

B. L. Bishop
Vice President—Sales
Bethlehem Steel Corporation

Edwin H. Gott
Chairman of the Board
United States Steel Corporation

Edward A. Curtis
Vice President for Public Affairs (Retired)
New Jersey Bell Telephone Co.

Kirk P. Pendleton
Vice President
Pitcairn Incorporated

E. H. Snyder
Board Chairman and Chief Executive Officer (Retired)
Public Service Electric & Gas Company

Biology

Robert K. Enders
Professor and Chairman of the Department of Biology
Swarthmore College

Dr. David Pratt
Professor of Oceanography
Narragansett Marine Laboratory

Dr. George W. de Villafranca
Professor of Zoology
Smith College

Dr. Robert P. Gilbert
Associate Dean
The Jefferson Medical College of Philadelphia

Dr. Frederick J. Pearson
Physician
Bethlehem, Pa.

H. P. McFadden
Partner
McFadden, Riskin and Huston

Business and Economics

Ross Robertson
School of Business Administration
Syracuse University

Ralph Gomory
T.J. Watson Research Center
Yorktown Heights, N.Y.

Morris Goldstein
Francis I. DuPont & Co., New York

Willis J. Winn
Dean, The Wharton School
University of Pennsylvania

Leonard M. Horton
Chairman of the Board
Aubrey G. Lanston & Company, Inc., New York City

Frank L. Magee
Chairman of the Board (Retired)
Aluminum Company of America

Chemical Engineering

John Arnold
Vice President for Engineering
Air Products & Chemicals, Inc.

P. L. T. Brian
Massachusetts Institute of Technology

Vernon W. Weekman, Jr.
Mobil Research Labs
Paulsboro, N.J.

Dr. Norman A. Copeland
Corporate Engineering Department
E. I. duPont de Nemours and Company

Dr. Stephen F. Goldmann
Esso Mathematics and Systems, Inc.

Dr. J. V. R. Kaufman
Deputy Director of Research, Development and Engineering
U. S. Army Material Command, Washington, D. C.

Alfred G. Blake
Chairman of the Board
Englehard Minerals and Chemical Corporation

Chemistry

John C. Bailar, Jr.
Professor of Inorganic Chemistry
University of Illinois

Ralph Connor
Chairman of the Board
Rohm and Haas Company

Frank G. Kear
Partner
Kear and Kennedy, Washington, D.C.

Edward E. Smissman
Chairman, Department of Medicinal Chemistry
University of Kansas

Charles N. Reilley
Department of Chemistry
University of North Carolina at Chapel Hill

Civil Engineering

S. M. Rust, Jr.
Chairman of the Board (Retired)
The Rust Engineering Company

Samuel S. Baxter
Consulting Engineer
Philadelphia, Pennsylvania

Hunter Rouse
Carver Professor of Mechanics and Hydraulics
The University of Iowa

Robley Winfrey
Consulting Engineer
Washington, D.C.

G. A. Leonards
Professor of Civil Engineering
Purdue University

Anton Tedesko
Consulting Engineer
Bronxville, New York

Classics

Dr. Frank C. Bourne
Professor of Classics
Princeton University

W. C. McDermott
Professor of Classical Studies
University of Pennsylvania

The Rev. Dr. Richard W. Corney
Department of Old Testament
The General Theological Seminary

The Rt. Rev. Dean T. Stevenson
Bishop
Diocese of Harrisburg

Computing Activities

Thomas E. Kurtz
Director, Kiewit Computation Center
Dartmouth College

S. J. Fenves
Professor of Civil Engineering
University of Illinois

R. G. E. Franks
Consultant, Engineering Services Department
E. I. duPont de Nemours and Company

L. R. Dimmick
General Manager, Corporate Data Processing
Bethlehem Steel Corporation

Dr. James F. Poage
Director of University Computing
Princeton University

Creative Arts

Philip Berman
President
Hess's Department Store, Allentown

Paul Kozelka
Professor of Speech and Theatre
Teachers College, Columbia University

Robert K. Beckwith
Professor and Chairman, Department of Music
Bowdoin College

Robert Spillman
Partner
Lovelace and Spillman, Bethlehem

Minott Coombs
Director of Dramatic Activity
Lafayette College

Ralph L. Wilson
Director of Metallurgy (Retired)
Timken Roller Bearing Company

Iva Dee Hiatt
Department of Music
Smith College, Northampton, Massachusetts

Electrical Engineering

Herbert J. Carlin
Head, Department of Electrical Engineering
Cornell University

W. Crawford Dunlap
Science Administrator to U. S. Transportation Systems Center, Cambridge, Massachusetts

William O. Fleckenstein
Executive Director
Bell Telephone Laboratories, Holmdel, N.J.

Charles H. Titus
Manager—Engineers
General Electric Company, Philadelphia

Joseph A. Waldschmitt
President
Page Communications, Washington, D.C.

Wayne H. Chen
Chairman, Department of Electrical Engineering
University of Florida

John F. Linvill
Executive Head, Department of Electrical Engineering
Stanford University

Edwin H. Snyder
Board Chairman (Retired)
Public Service Electric & Gas Co., New Jersey

G. B. Herzog
Director, Solid State Technology Center
RCA, Somerville, N.J.

English

James T. Nardin
Professor of English
Louisiana State University

Robert M. Lumiansky
Professor and Chairman of the Department of English
University of Pennsylvania

Edwin H. Miller
Professor of English
New York University

David C. Phillips
Professor and Head of the Department of Speech
University of Connecticut

Maurice J. Quinlan
Professor of English
Boston College

John Strohmeyer
Vice President and Editor
Bethlehem (Pa.) Globe-Times

Charles T. Prouty
Professor of English
Yale University

Geological Science

James Boyd
Executive Director
National Commission on Materials Policy, Washington, D. C.

Richard H. Jahns
Dean, School of Earth Sciences
Stanford University

Edwin W. Roedder
U.S. Geological Survey, Washington, D.C.

Donald B. Stabler
President
Stabler Construction Co.

Melvin J. Hill
Vice President and Coordinator
Gulf Oil Corporation, Pittsburgh, Pa.

Gilbert L. Hole
Chief Geologist, Mining-Geology
Bethlehem Steel Corporation

Government

Henry J. Abraham
Professor of Political Science
University of Pennsylvania

Edward N. Cahn
Partner
Dower, Huston and Cahn, Allentown

Carl Schier
Assistant Professor of Law
Urban Law Program, School of Law, University of Detroit

H. Gordon Payrow
Mayor
City of Bethlehem

Alfred E. Driscoll
President
Warner-Lambert Pharmaceutical Co.

Peter W. Rodino, Jr.
Member, U.S. House of Representatives
(10th District, New Jersey)

Edward A. Curtis
Vice President (Retired)
New Jersey Bell Telephone Company

History

Robert D. Cross
Dean of Faculty
University of Virginia

Laurence C. Howard
Dean, Graduate School
University of Pittsburgh

George T. Peck
Vice President (Retired)
Peck and Peck

Joseph R. Strayer
Dayton-Stockton Professor
Princeton University

Paul A. Varg
Professor of History and Dean of the College of Arts and Letters
Michigan State University

Henry R. Winkler
Vice President for Academic Affairs
Rutgers University

Morgan J. Cramer
President and Chief Executive Officer (Retired)
P. Lorillard and Company, Inc.

Industrial Engineering

Marvin E. Gantz
Vice President—Manufacturing
Aluminum Company of America

Andrew Schultz
Dean of Engineering
Cornell University

E. H. Gott
Chairman of the Board
United States Steel Corporation

J. E. Angle
Executive Vice President—Production
United States Steel Corporation

Paul D. O'Donnell
Director—Manufacturing, Planning and Control
Westinghouse Electric Corporation

International Relations

Morton Blaustein
President
Blaustein Industries

Robert Bowie
Director
Center for International Affairs, and Clarence Dillon Professor of International Affairs
Harvard University

Richard A. Falk
Albert G. Milbank Professor of International Law and Practice
Princeton University

Monroe J. Rathbone
Chairman of the Board (Retired)
Standard Oil Company (New Jersey)

Frederick Seitz
President
Rockefeller University

Library

John H. Berthel
Librarian, Milton S. Eisenhower Library
The Johns Hopkins University

Carl Jackson
Dean of Library Administration
Indiana University

Thomas R. Adams
Librarian, John Carter Brown Library
Brown University

David Kaser
Director of Libraries
Cornell University

Thomas H. Mott
Dean, Graduate School of Library Science
Rutgers University

Dr. Jack Vanderryn
Technical Assistant to the Director of the Division of Applied Technology, U. S. Atomic Energy Commission, Washington, D. C.

Center for Marine and Environmental Studies

Dr. Scott C. Daubin
Chairman, Ocean Engineering Department
University of Miami, Florida

Melvin W. First
Professor of Environmental Health Services
School of Public Health, Harvard University

George H. Keller
Director, Marine Geology & Geophysics Laboratory
Atlantic Oceanographic Laboratory, National Oceanic and Atmospheric Administration, Miami, Florida

J. M. Prescott
Dean, College of Science
Texas A & M University

George T. Scott
Professor of Biology
Oberlin College

Robert Wright, Jr.
Manager, Permasep Products
E. I. duPont de Nemours and Company

Mathematical Science

The Visiting Committee for the Mathematical Sciences oversees the work not only of the Department of Mathematics, but also that of the Center for the Application of Mathematics, Department of Philosophy and Center for the Information Sciences.

Vincent E. Guiliano
Arthur D. Little, Inc.

Paul Halmos
Professor of Mathematics
University of Indiana

Henry O. Pollack
Bell Telephone Laboratories, Inc.

F. J. Weyl
Dean of Sciences and Mathematics
Hunter College

Mechanical Engineering and Mechanics

Howard W. Emmons
Professor of Mechanical Engineering
Harvard University

Edward G. Uhl
President and Chief Executive Officer
Fairchild Industries, Inc.

G. Douglas Reed
Vice President—Manufacturing
McCormick and Company, Baltimore, Md.

George F. Carrier
Professor of Mechanical Engineering
Harvard University

Daniel C. Drucker
Dean, College of Engineering
University of Illinois

Leo Steg
Manager
Space Science Laboratory, General Electric Company, Valley Forge, Pa.

Metallurgy and Materials Science

Donald Blickwede
Vice President and Director of Research
Bethlehem Steel Corporation

Morris Fine
Professor of Materials Science
Northwestern University

Walter Hibbard
Vice President, Research and Development
Owings-Corning Fiberglas

Nathan Promisel
Executive Director
Materials Advisory Board, National Research Council, National Academy of Sciences

Ralph T. Wilson
Director of Metallurgy (Retired)
Timken Roller Bearing Co.

L. H. Van Vlack
Department of Metallurgy and Materials Science
University of Michigan

Dr. N. Bruce Hannay
Bell Telephone Laboratories

Eric Baer
Case Western Reserve University

W. O. Philbrook
Department of Metallurgy and Materials Science
Carnegie-Mellon University

Modern Foreign Languages and Literatures

William Hittinger
Vice President and General Manager
Radio Corporation of America

Dr. Harold Jantz
Professor of German
Johns Hopkins University

Dr. Robert G. Mead, Jr.
Professor of Foreign Languages
University of Connecticut

Dr. Edward D. Sullivan
Dean of the College and Professor of French
Princeton University

Physics

John F. Clark
Director
Goddard Space Flight Center, Greenbelt, Md.

Ira G. Hedrick
Vice President—Engineering
Grumman Aircraft Engineering Corporation, Bethpage, N.Y.

Frederick C. Brown
Physics Department
University of Illinois

Sidney Millman
Director of Physics Research
Bell Telephone Laboratories, Murray Hill, N.J.

Robert Serber
Professor of Physics
Columbia University

Robert H. Dicke
Department of Physics
Princeton University

John Galt
Director, Solid State Electronics Research Laboratories
Bell Telephone Laboratories

Psychology

Frank Geldard
Professor of Psychology
Princeton University

Harold Gulliksen
Center for Psychological Studies
Educational Testing Service, Princeton, N.J.

Richard Solomon
Professor of Psychology
University of Pennsylvania

Richard Trumball
Office of Naval Research, Washington, D.C.

H. P. McFadden
Partner
McFadden, Riskin and Huston, Bethlehem

Social Relations

Robert Bierstedt
Department of Sociology
University of Virginia

Kenneth J. Gergen
Chairman, Department of Psychology
Swarthmore College

Donald R. Young
President (Retired)
Russell Sage Foundation

H. P. McFadden
Partner
McFadden, Riskin and Huston, Bethlehem

Harry C. Bredemeier
Department of Sociology
Rutgers University

University Administration

Administration

Office of the President

Willard Deming Lewis, Ph.D., LL.D., L.H.D.
President

Albert Charles Zettlemoyer, Ph.D., D.Sc.
Provost and Vice President

Paul Justus Franz, Jr., M.A.
Vice President—Development

Joseph Francis Libsch, Sc.D.
Vice President—Research

Preston Parr, M.S.
Dean and Vice President—Student Affairs

Elmer William Glick, B.A.
Vice President and Treasurer

Richard Moore Spriggs, Ph.D.
Vice President—Administration

Eric Van Tine Ottervik, Ph.D.
Vice Provost and Coordinator of University Planning

Mary Isabelle Malone, B.A.
Secretary to the President

Robert Sayre Taylor, LL.B.
Legal Counsel

Academic Offices

John J. Karakash, M.S.
Dean, College of Engineering

John A. Stoops, Ed.D.
Dean, School of Education

Robert Daniel Stout, Ph.D.
Dean, Graduate School

Brian George Brockway, LL.M.
Dean, College of Business and Economics

John W. Hunt, Ph.D.
Dean, College of Arts and Science

George Mark Ellis, Ph.D.
Assistant Dean, College of Arts and Science

Robert Taylor Gallagher, D.E.M.
Associate Dean, College of Engineering

Max Donald Snider, M.B.A.
Assistant Dean, College of Business and Economics

Norman Harold Sam, Ed.D.
Director, Summer Session

Nan Van Gieson, Ph.D.
Assistant Dean, School of Education and Assistant Director, Summer Session

Berry Gargal Richards, M.L.S.
Secretary to the Faculty

Student Personnel Services

Office of the Dean of Students

Charles Wilfrid Brennan, M.B.A.
Dean of Students

Arthur Howard Mann, S.T.B.
Associate Dean of Students

Office of the Dean of Student Life

William Leroy Quay, Ph.D.
Dean of Student Life

Ruth Ann Hurley, M.S.
Associate Dean of Student Life

Nathan Walter Harris, B.S.
Assistant Dean of Student Life

Joseph Hurley Reynolds, M.A.
Assistant to the Dean of Student Life

Barbara Elizabeth Solt, M.S.S.W.
Coordinator of Volunteer Community Services

Office of the Dean of Residence

Clarence Bowen Campbell, M.A.
Dean of Residence

Robert Peter Shurtleff, M.Ed.
Director of Residence Halls, Assistant Dean of Residence

Evelyn Strawn Eberman, B.A.
Assistant Director of Residence Halls

James A. Tiefenbrunn, M.B.A.
Assistant Director of Residence Halls, Assistant Dean of Residence

Business Offices

Donald Walter Schmoyer, B.S. in Bus. Adm.
Assistant Treasurer

Joseph Petronio, B.S.
Bursar

Lou V. Forcum
Assistant Bursar

Albert Charles Molter, M.S.
Purchasing Agent

John Lester Kemmerer
Assistant Purchasing Agent

William Monroe Glose III, B.S. in Bus. Adm.
Accountant

Larry M. Miley, B.S. in Bus. Adm.
Assistant Accountant

Clark W. Hahn, B.A.
Assistant Accountant

Robert Warren Numbers, B.S.
Director, Physical Plant

Paul Theodore Miller
Superintendent, Buildings and Grounds

Kenneth E. Orben, B.S. in E.E.
Assistant Superintendent, Buildings and Grounds

Frank S. Donchez
Captain of Police

Robert W. Bell, M.S.
Director, Bookstore

Stanley Frederick Heffner
Manager, Bookstore

Kenneth M. Trumbore, B.A.
Assistant Manager, Bookstore

Office of the Registrar

James Harold Wagner, M.A.
Registrar

Frederick Eugene Ressler, A.B.
Associate Registrar

Rodney Earl Ressler
Assistant Registrar

Claire C. Biser
Assistant Registrar

Office of Development

Robert Mark Holcombe, M.S.
Director of Development

Michael G. Bolton, M.B.A.
Director of Corporate and Foundation Resources

Charles Keller Zug, B.S.
Advisor, Bequests, Trusts and Insurance

Austin V. McClain, M.A.
Consultant

Stuart R. Christie, B.A.
Assistant to the Director

Office of Community Relations

James W. Harper, M.S.
Director

Office of Physical Planning

H. Joris Rosse, B.A.
Director

Ronald J. Horvath, B.A.
Assistant Planner

Anne C. Solderitsch
Assistant to the Planner

Office of Public Information

Samuel Irvin Connor, B.A.
Director

Roy Foster, Jr., B.A.
Assistant Director

Joseph Hardy Whritenour
Assistant Director

Janet Donna Connor, M.A.
Assistant to the Director

Diane Kay Shaffer, B.S.
Assistant to the Director

Office of University Publications

George Leonard Beezer, B.A.
Director

Marvin Howard Simmons, M.A.
Assistant Director

Lynn Dianne Klein, B.A.
Production Assistant

Sara Louise Paden, B.A.
Administrative Assistant

Office of Admission

Samuel Harold Missimer, B.A.
Director

James Willard McGeady, B.A.
Associate Director

Robert F. Reeves, B.A.
Assistant Director

Linda L. Tipton, B.A.
Assistant to the Director

Office of Undergraduate Financial Aid

William Edward Stanford, B.A.
Director

Deborah J. Dwyer, B.S.
Assistant to the Director

Alumni Association

James W. Niemeyer, B.S.
Executive Director

Harry B. Ramsey, B.A.
Associate Executive Director, Editor, Alumni Bulletin

Dennis R. Diehl, M.B.A.
Assistant to the Executive Director

Lucile Barrett, A.B.
Assistant to the Editor, Alumni Bulletin

Margaret E. F. Rocheleau, B.A.
Assistant to the Editor, Alumni Bulletin

University Libraries

James Decker Mack, M.A.
Director of Libraries

Lorraine C. Abel
Assistant to the Director

Brian Sanders, M.A.
Associate Librarian, Linderman Library

Berry Gargal Richards, M.L.S.
Associate Librarian, Mart Library

Margaret Linn Dennis, B.S. in L.S.
Assistant Librarian, Readers' Service

Mary Gruber Riley, M.S. in L.S.
Head Reference Librarian, Linderman Library

Alice Frances Bahr, B.A.
Assistant Reference Librarian

Margaret N. Smith, M.L.S.
Assistant Librarian, Acquisitions

Georgia Emily Raynor, M.S. in L.S.
Assistant Librarian, Cataloging

Catherine Riley Flecksteiner
Serials Cataloger

William J. Fincke, Jr., M.L.S.
Social Science Cataloger

Caroline Cochrane Nippert, M.L.S.
Science Cataloger

Daniel J. Weine, A.M.L.S.
Humanities Cataloger

Sharon Matley Siegler, M.L.S.
Reference Librarian, Mart Library

Kenneth J. Veprek, M.S.L.S.
Reference Librarian, Mart Library

Olive Stengel
Circulation Supervisor

Clara M. Fistner
Xerox Technician

Packer Memorial Chapel

The Rev. Hubert L. Flesher, M.A.
Chaplain

Robert Benjamin Cutler, M.A.
Organist

University Placement and Personnel Services

Everett Anderson Teal, M.A.
Director

Edward J. Trost, M.A.
Assistant Director of Personnel

Richard B. Fisher, M.A.
Assistant Director of Placement

Helen Z. Rayner
Administrative Assistant

University Counseling Services

Andrew J. Edmiston, Ph.D.
Director

Robert Roupen Panos, Ph.D.
Assistant Director

William Joseph Sibley, M.Ed.
Counselor

Patricia A. Finady, B.A.
Administrative Assistant

University Health Service

P. Lawrence Kreider, M.D.
Acting Director

Duane E. Stackhouse, M.D.
Associate Director

Lucille H. Pleiss, R.N.
Administrative Assistant

Doris Transue, R.N.
Nurse

Dorothy Delp, R.N.
Nurse

James P. Mathews
Physical Therapist

Division of Intercollegiate Athletics and Physical Education

William Bader Leckonby, B.S.
Director of Athletics and Physical Education

Gerald Grant Leeman, B.S.
Assistant to the Director of Athletics

N. Craig Anderson
Business Manager

John S. Steckbeck, M.Sc.
Director of Intramurals and Recreation and Assistant Director of Physical Education

Helen S. Bond, B.S.
Assistant Director of Women's Physical Education

J. Bruce Gardiner, M.Sc.
Physical Education Assistant

Administrative Services

Thomas Joseph Verbonitz, M.B.A.
Director

Administrative Systems Office

William J. McGarry, M.B.A.
Director

Wayne Hoffman
Assistant Director

David L. March, Ph.D.
Systems Programmer

Kathleen A. Kemmerle, B.S.
Systems Programmer

Barbara Long
Systems Programmer

Mailing and Central Copying Office

Catherine Franklin
Director

Centers and Institutes

Office of Research

George Robert Jenkins, Ph.M.
Director

John M. Cheezum, B.S.
Fiscal Associate

Mary Jo Hill, M.A.
Editorial Associate

Center for the Application of Mathematics

Ronald S. Rivlin, Sc.D.
Director

Philip A. Blythe, Ph.D.
Dominic G. B. Edelen, Ph.D.
Gregory T. McAllister, Ph.D.
Gerald F. Smith, Ph.D.
Eric Varley, Ph.D.
Eric P. Salathe, Ph.D.
Rolf K. Adenstedt, Ph.D.
Anastasios Kydoniefs, Ph.D.
Ramamirtham Venkataraman, Ph.D.
Yakovos Kazakia, Ph.D.

Kenneth N. Sawyers, Ph.D.
Executive Officer

Computing Center

John E. Walker, Ph.D.
Director, Computing Center & Associate Professor, Economics

John E. Smith, M.A.
Manager, Computer Service

William F. Hollabaugh, Ph.D.
Manager, Systems Programming

Joseph F. Scullion, Jr., B.S.
Manager, Special Projects and Program Development

Joseph P. Holzer
Administrative Assistant

Robert A. Pfenning, M.B.A.
Coordinator, User Services

Carol D. Rauch
Librarian

Gary E. McConnell, B.S.
Group Leader, Applications Programming

John H. Morrison
Operations Supervisor

William E. Schiesser, Ph.D.
Analyst, Computing Center & Professor of Chemical Engineering

Center for Health Sciences

Institute for Pathobiology

Thomas C. Cheng, Ph.D.
Director
Experimental Parasitology; Immunology; Invertebrate Pathology

Edward J. Benz, M.D.
Medical Microbiology

Ann Cali, Ph.D.
Protozoology; Electron Microscopy

Henry N. Fremount, Dr. PH.
Protozoology; Electron microscopy; Malariology

Sidney S. Herman, Ph.D.
Director of the South Jersey Wetlands Institute; Pollution Biology

Richard G. Malsberger, Ph.D.
Virology; Tissue Cultures

Randall W. Snyder, Jr., M.D.
Medical Parasitology; Gastrointestinal physiology

Division of Biological Chemistry and Biophysics

Ned D. Heindel, Ph.D.
Director
Medicinal Chemistry; Bioorganic Chemistry

Brent W. Bensen, Ph.D.
Radiation biophysics; Tructure of nucleic acids

Frederick M. Fowkes, Ph.D.
Physical chemistry of biological surfaces

Joseph R. Merkel, Ph.D.
Microbial enzyme biochemistry

William E. Ohnesorge, Ph.D.
Clinical chemistry

Keith Schray, Ph.D.
Intermediary metabolism; Enzyme kinetics

Thomas E. Young, Ph.D.
Biosynthetic pathways; Melanin biochemistry

Eugene W. Rice, Ph.D.
Clinical chemistry

Division of Bioengineering

Arturs Kalnins, Ph.D.
Director
Physical properties of cell surfaces

Russell E. Benner, Ph.D.
Prosthetics

Nikolai Eberhart, Ph.D.
Bioinstrumentation

George Krauss, Jr., Ph.D.
Fine structure; Biological implants

Dean P. Updike, Ph.D.
Properties of biological surfaces

Division of Visual Science

George K. Shortess, Ph.D.
Director
Psychobiology of vision; Neurophysiology

Eugene Allen, Ph.D.
Color Science

William A. Barrett, Ph.D.
Instrumentation as applied to vision research

Ernest E. Bergman, Ph.D.
Optics; Laser physics

Sidney Stecher, Ph.D.
Visual discrimination

Center for Information Science

Donald John Hillman, M.Litt.
Director

Andrew James Kasarda, Ph.D.
Associate Director

Herbert Rubenstein, Ph.D.
Psycholinguistics

John J. O'Connor, Ph.D.
Information Retrieval

Robert Featherstone Barnes, Jr., Ph.D.
Mathematical Linguistics

James Sproat Green, Ph.D.
Special Projects

Louis W. Stern, Ph.D.
Batch Services

Lawrence J. Davis, M.S.
Assistant to the Director

Associates

Robert Clifford Williamson, Ph.D.
Man-Machine Interface

James D. Mack, M.A.
Library Systems

Berry Gargal Richards, M.L.S.
Library Automation

Sharon L. Siegler, M.L.S.
LEADERMART User Services

John E. Walker, Ph.D.
Computing Liaison

Lynn S. Beedle, Ph.D.
Tall Buildings Information Systems

Center for Marine and Environmental Studies

James Marshall Parks, Ph.D.
Director

Joseph R. Merkel, Ph.D.
Director, Marine Biochemistry Laboratory

Adrian F. Richards, Ph.D.
Director, Marine Geotechnical Laboratory

Sidney Samuel Herman, Ph.D.
Director, South Jersey Wetlands Institute

Robert L. Johnson, Ph.D.
Director, Environmental Engineering Laboratory

Saul Benjamin Barber, Ph.D.
Physiology of Invertebrates

Arthur William Brune, Ph.D.
Hydrology

Bobb Carson, Ph.D.
Oceanic Sedimentology

Robert William Coughlin, Ph.D.
Air Pollution Studies

Jacob De Rooy, Ph.D.
Econometric Modeling

Alfred James Diefenderfer, Ph.D.
Analytical Chemistry

Walter H. Graf, Ph.D.
River and Oceanographic Hydraulics

Terence J. Hirst, Ph.D.
Associate Director, Marine Geotechnical Laboratory

Matthew H. Hulbert, Ph.D.
Analytical Chemistry

John B. Pearce, Ph.D.
Benthic Ecology

John Donald Ryan, Ph.D.
Sedimentology

Alan Hugh Stenning, Sc.D.
Geophysical Fluid Dynamics

Theodore Alfred Terry, Ph.D.
Instrument Design

Wesley J. Van Sciver, Ph.D.
Marine Optics, Nuclear Applications

Center for Surface and Coatings Research

Henry Leidheiser, Jr., Ph.D.
Director

John W. Vanderhoff, Ph.D.
Associate Director—Coatings, and Director, NPIRI

Jacqueline Marie Fetsko, M.S.
Administrative Assistant

Eugene M. Allen, Ph.D.
Color Science Laboratory

Robert William Coughlin, Ph.D.
Fine Particle Dispersions

Frederick M. Fowkes, Ph.D.
Surface Chemistry

Kamil Klier, Ph.D.
Catalysis

Fortunato Joseph Micale, Ph.D.
Colloid Chemistry

Gary Wayne Poehlein, Ph.D.
Rheology

Gary W. Simmons, Ph.D.
Electron Spectroscopy

Robert Peh-Ying Wei, Ph.D.
Stress Corrosion, Corrosion Fatigue

John D. Wood, Ph.D.
Stress Corrosion

Albert C. Zettlemoyer, Ph.D.
Surface Chemistry and Wetting

Research Associates

Mohammed S. El-Aasser, Ph.D.
Elsie Kellerman, Ph.D.
Richard Kellerman, Ph.D.
Mladen Topic, Ph.D.

Center for Social Research

L. Reed Tripp, Ph.D.
Acting Coordinator
Director, Manpower Research

Roy Herrenkohl, Ph.D.
Director, Behavioral Science Program

J. Richard Aronson, Ph.D.
Director, Business and Economics Program

Leonard Ruchelman, Ph.D.
Director, Urban Studies Program

Charles Brownstein, Ph.D.
Urban Studies Program

Robert Thornton, Ph.D.
Manpower Studies

Fritz Engineering Laboratory

Lynn Simpson Beedle, Ph.D.
Director

George C. Driscoll, Jr., Ph.D.
Associate Director

John W. Fisher, Ph.D.
Associate Director

Bruce A. Laub, M.B.A.
Administrative Assistant

Deborah J. Ritter, B.A.
Administrative Assistant

Lambert Tall, Ph.D.
Director, Fatigue and Fracture Division

Hsai-Yang Fang, Ph.D.
Director, Geotechnical Engineering Division

Walter H. Graf, Ph.D.
Director, Hydraulics and Sanitary Engineering Division

Le-Wu Lu, Ph.D.
Director, Building Systems Division

Ti Huang, Ph.D.
Director, Structural Concrete Division

John W. Fisher, Ph.D.
Director, Structural Connections Division

Alexis Ostapenko, Ph.D.
Director, Structural Stability Division

Roger C. Slutter, Ph.D.
Director, Operations Division

Celal N. Kostem, Ph.D.
Chairman, Computer Systems Group

Kenneth R. Harpel
Laboratory Superintendent

Hugh T. Sutherland
Instruments Associate

Associates

Arthur W. Brune, Ph.D.
Wai-Fah Chen, Ph.D.
J. Hartley Daniels, Ph.D.
Terence J. Hirst, Ph.D.
Robert L. Johnson, Ph.D.
Willard A. Murray, Ph.D.
Richard Roberts, Ph.D.
Paul J. Usinowicz, Ph.D.
David A. VanHorn, Ph.D.
Robert P. Y. Wei, Ph.D.
B. T. Yen, Ph.D.

Materials Research Center

Donald M. Smyth, Ph.D.
Director

David A. Thomas, Ph.D.
Associate Director, and Director, Materials Liaison Program

Sidney R. Butler, Ph.D.
Director, Advanced Materials Laboratory

Walter E. Dahlke, Ph.D.
Advanced Materials Laboratory

Frank J. Feigl, Ph.D.
Advanced Materials Laboratory

D. P. H. Hasselman, Ph.D.
Director, Physical Ceramics Laboratory

Richard Warren Hertzberg, Ph.D.
Director, Mechanical Behavior Laboratory

R. Wayne Kraft, Ph.D.
Advanced Materials Laboratory

George Krauss, Jr., Sc.D.
Electron Microscopy Laboratory

John Alexander Manson, Ph.D.
Director, Polymer Laboratory

Michael R. Notis, Ph.D.
Advanced Materials Laboratory

Richard Roberts, Ph.D.
Mechanical Behavior Laboratory

Leslie H. Sperling, Ph.D.
Polymer Laboratory

Richard Moore Spriggs, Ph.D.
Physical Ceramics Laboratory

Lawrence Henry Gipson Institute for Eighteenth-Century Studies

Lawrence H. Leder, Ph.D.
Coordinator

Peter Beidler, Ph.D.
Josef M. Brozek, Ph.D.
Ernest N. Dilworth, Ph.D.
Jonathan B. Elkus, M.A.
Edward J. Gallagher, Ph.D.
E. Anthony James, Ph.D.
J. Ralph Lindgren, Ph.D.
John B. Owens, Ph.D.
Richard J. Redd, M.F.A.
James S. Saeger, Ph.D.
John A. Van Eerde, Ph.D.
D. Alexander Waldenrath, Ph.D.
Robert C. Williamson, Ph.D.
W. Ross Yates, Ph.D.

Institute of Fracture and Solid Mechanics

George C. M. Sih, Ph.D.
Director

Robert Badaliance, M.S.
Tony E. P. Chen, Ph.D.
Fazil Erdogan, Ph.D.
Ronald J. Hartranft, Ph.D.

Peter D. Hilton, Ph.D.
Arturs Kalnins, Ph.D.
Marlin E. Kipp, M.S.
Robert A. Lucas, Ph.D.
Richard Roberts, Ph.D.
Robert G. Sarubbi, Ph.D.
Dean P. Updike, Ph.D.
Robert P. Y. Wei, Ph.D.

Institute for Metal Forming

Betzalel Avitzur, Ph.D.
Director

Walter C. Hahn, Ph.D.
Program Manager

South Jersey Wetlands Institute

Sidney S. Herman, Ph.D.
Director
Biological oceanography, marine ecology, food chain relationships

Saul B. Barber, Ph.D.
Physiology of invertebrates

David M. Bell, Ph.D.
Behavior of marine animals

Bobb Carson, Ph.D.
Geological oceanography

Thomas C. Cheng, Ph.D.
Marine symbiosis, shellfish pathobiology, invertebrate immunobiology, parasitology

A. James Diefenderfer, Ph.D.
Analytical chemistry, instrumentation

Walter Graf, Ph.D.
Hydraulics of sediment transport

Ned D. Heindel, Ph.D.
Photochemistry

Matthew H. Hulbert, Ph.D.
Chemical oceanography

Robert L. Johnson, Ph.D.
Tertiary sewage treatment

Richard G. Malsberger, Ph.D.
Viral diseases of fish

Joseph R. Merkel, Ph.D.
Biochemistry of marine bacterial enzymes

James M. Parks, Ph.D.
Beach preservation

Hayden N. Pritchard, Ph.D.
Chemical oceanography

J. Donald Ryan, Ph.D.
Geological history of coastal salt marshes, sedimentation

Faculty & Staff

The first date after the name indicates the date of first appointment to continuous service on the faculty or staff; the second date, when the first fails to do so, indicates the date of appointment to present professional rank. Listings of emeriti faculty, and those members of the faculty and staff deceased, retired, or resigned in the past year are noted at the end of this section.

Lorraine C. Abel (1969)
Assistant to the Director of Libraries

Benjamin L. Abramowitz (1972)
Professor of Military Science
B.S., Virginia Polytechnic Institute, 1955; M.B.A., George Washington, 1971.
Lt. Col., Army.

Ljubisa S. Adamovic (1973)
Visiting Professor of Economics

John William Adams (1969)
Associate Professor of Industrial Engineering
B.S., University of Nebraska, 1952; Ph.D., University of North Carolina, 1962.

Rolf K. Adenstadt (1969)
Assistant Professor, Center for the Application of Mathematics
B.S., Brown, 1963; Ph.D., 1967.

David Adkins (1972)
Staff Assistant, Aerospace Studies
Staff Sergeant, U.S.A.F.

Eugene Murray Allen (1967)
Professor of Chemistry and Director, Color Science Laboratory, CSCR
B.A., Columbia, 1938; M.S., Stevens Institute of Technology, 1944; Ph.D., Rutgers, 1952.

Goren Alpstein (1967)
Postdoctoral Research Associate in Civil Engineering
Teknologie Licentiat—Royal, Institute of Technology (Sweden), 1967.

Carlos J. Alvare (1968, 1969)
Associate Professor of Fine Arts
B.A., Yale, 1947; M.C.P., Penn, 1952; M.Arch., Yale, 1973.

David C. Amidon, Jr. (1965, 1971)
Lecturer in Social Relations
B.A., Juniata College, 1957; M.A., Penn State, 1959.

Norman Craig Anderson (1966, 1968)
Business Manager, Athletics
B.S., Lehigh, 1960; M.S., Southern Illinois, 1964.

Kemal Arin (1969)
Assistant Professor of Mechanics
M.S., Technical University of Istanbul, 1963; Ph.D., Lehigh, 1969.

Ray Livingstone Armstrong (1946, 1970)
Professor of English
B.A., Williams, 1930; B.A., Oxford, 1932; M.A., 1936; Ph.D., Columbia, 1941.

Jay Richard Aronson (1965, 1972)
Professor of Economics
A.B., Clark, 1959; M.A., Stanford, 1961; Ph.D., Clark, 1964.

Edward F. Assmus, Jr. (1966, 1970)
Professor of Mathematics
A.B., Oberlin, 1953; A.M., Harvard, 1955; Ph.D., 1958.

Betzalel Avitzur (1964, 1968)
Professor of Metallurgy and Materials Science and Director, Institute for Metal Forming
B.Sc. and Dip. Ing., Israel Institute of Technology, 1949; M.S., Michigan, 1956; Ph.D., 1960.

Dunham R. Bainbridge (1972)
Instructor in Accounting
B.S., Rider, 1963; M.S., Lehigh, 1972. C.P.A., 1971.

Alice Frances Bahr (1971)
Assistant Reference Librarian, Linderman Library
B.A., Temple, 1968; M.L.S., Drexel, 1971.

Nicholas W. Balabkins (1957, 1966)
Professor of Economics
Dipl. rer. pol., Gottingen, 1949; M.A., Rutgers, 1953; Ph.D., 1956.

Saul Benjamin Barber (1956, 1965)
Professor of Biology
B.S., Rhode Island State, 1941; Ph.D., Yale, 1954.

Thoburn Vail Barker (1953,1962)
Associate Professor of Speech
B.A., Ohio Wesleyan, 1943; M.A., Columbia, 1951.

Robert Featherstone Barnes, Jr. (1965)
Associate Professor of Philosophy
B.S., M.I.T., 1957; M.A., Dartmouth, 1959; Ph.D., Berkeley, 1965.

David Barrett III (1971)
Instructor in Education
B.S., West Chester, 1954; M.Mus., Boston, 1962.

Lucile Lewis Barrett (1944, 1970)
Assistant to the Editor, Alumni Bulletin
A.B., Syracuse, 1939.

William A. Barrett (1966, 1968)
Associate Professor of Electrical Engineering
B.S., Nebraska, 1952; M.S., 1953; Ph.D., Utah, 1957.

Donald Delyle Barry (1963, 1970)
Professor of Government
A.B., Ohio, 1956; M.A., Syracuse, 1959; Ph.D., 1963.

Sandra Lee Bartoli (1970)
Instructor in Education, Centennial School
B.S., St. Joseph's College (Maryland), 1963; M.S., Shippensburg, 1968.

Frederick Baus (1971)
Instructor in Education
A.B., Muhlenberg, 1967; M.A., Lehigh, 1968.

Edward G. Becker (1971)
Instructor in Military Science
SSG, U.S. Army.

Lynn Simpson Beedle (1947, 1957)
Professor of Civil Engineering; Director, Fritz Engineering Laboratory
B.S. in C.E., Berkeley; M.S., Lehigh, 1949; Ph.D., 1952.

Ferdinand Pierre Beer (1947, 1957)
Professor and Chairman of the Department of Mechanics and Mechanical Engineering
B.S., Geneva (Switzerland), 1933; M.S., 1935; Ph.D., 1937; M.S., Paris, 1938.

George L. Beezer (1973)
Director, University Publications
B.A., Lehigh, 1957.

Carl Robert Beidleman (1967, 1972)
Associate Professor of Finance
B.S., Lafayette, 1954; M.B.A., Drexel, 1961; Ph.D., Penn, 1968.

Peter Grant Beidler (1963, 1972)
Associate Professor of English
B.A., Earlham, 1962; M.A., Lehigh, 1965; Ph.D., 1968.

David Morgan Bell (1972)
Assistant Professor of Biology
B.A., Lehigh 1967; Ph.D., Stanford, 1972.

Raymond Bell (1966, 1971)
Assistant Professor of Education
Teaching Certificate, St. John's College, York (England), 1961; B.A., Leed U. Institute of Education (England); M.A., Temple, 1966; Ed.D., Lehigh, 1971.

Robert W. Bell (1969)
Director, University Bookstore
B.S., New York at Albany, 1952; M.S., 1960.

Russell Edward Benner (1962)
Professor of Mechanical Engineering
B.M.E., Cornell, 1947; M.S. in M.E., Lehigh, 1951; Ph.D., 1959. P.E., Pennsylvania, 1970.

Grahame Bennett (1970)
Visiting Lecturer in Mathematics
B.Sc., Newcastle, 1966.

Brent W. Benson (1972)
Associate Professor of Physics
B.A., Knox College, 1963; M.S., 1965; Ph.D., Penn State, 1969.

Edward John Benz (1956, 1963)
Adjunct Professor of Medical Microbiology
B.S., Pittsburgh, 1944; M.D., 1946; M.S., Minnesota, 1952.

Ernest E. Bergmann (1969)
Assistant Professor of Physics
A.B., Columbia, 1964; M.A., Princeton, 1966; Ph.D., 1969.

Bartus Hendrik Bijsterbosch (1969)
Visiting Assistant Professor, Center for Surface and Coatings Research
B.S., State University of Utrecht (Netherlands), 1965; M.S., 1959; Ph.D., 1965.

Claire C. Biser (1970, 1972)
Assistant Registrar

Hartwig R. F. Blume (1967)
Research Associate in Physics
Dipl. Phys., University of Freiburg (Germany), 1962; Ph.D., 1967.

Philip Anthony Blythe (1968, 1970)
Professor, Center for the Application of Mathematics
B.S., University of Manchester (England), 1958; Ph.D., 1961.

George H. Bodnar (1973)
Instructor in Accounting
B.S. Bucknell, 1970.

Michael G. Bolton (1971)
Director of Corporate and Foundation Resources
B.A., 1966; M.B.A., Lehigh, 1967.

Helen S. Bond (1972)
Assistant Director of Women's Physical Education
B.S., Youngstown, 1956.

John W. Bonge (1972)
Associate Professor of Management
B.S., Princeton, 1957; M.B.A., 1959; Ph.D., Northwestern, 1968.

Garold Joseph Borse (1966, 1971)
Associate Professor of Physics
B.S., Detroit, 1962; M.S., Virginia, 1964; Ph.D., 1966.

Richard C. Brace (1970)
Assistant Professor of Aerospace Studies
B.A., Buffalo, 1957; B.S., Air Force Institute of Technology, 1965; M.A.O.M., Berkeley, 1967. Major, USAF.

Henderson Bampfield Braddick (1956, 1972)
Professor of International Relations
A.B., Washington, 1942; LL.B., Harvard, 1949; Ph.D., Washington, 1957.

Charles Wilfrid Brennan (1955, 1964)
Dean of Students
B.S., Alabama, 1934; M.B.A., 1953.

Frank S. Brenneman (1968)
Assistant Professor of Mathematics
B.A., Goshen, 1960; M.A., Penn State, 1965; Ph.D., Oklahoma State, 1967.

Delford G. Britton (1971)
Assistant Professor of Aerospace Studies
B.A., Santa Clara, 1961; M.A., Southern California, 1969. Captain, USAF.

Brian George Brockway (1971)
Dean of the College of Business and Economics, Professor of Law
B.S., Northwestern, 1957; LL.B., Georgetown, 1961; LL.M., 1963.

Arthur L. Brody (1957, 1971)
Professor and Chairman of Psychology
B.A., George Washington, 1951; Ph.D., Indiana, 1956.

Addison C. Bross (1967)
Assistant Professor of English
B.A., Davidson, 1959; M.A., Duke, 1960; Ph.D., Louisiana State, 1967.

Forbes Taylor Brown (1970)
Professor of Mechanical Engineering
S.B., M.I.T., 1958; S.M., 1959; Sc.D., 1962.

Charles W. Brownstein (1971)
Assistant Professor of Government
A.B., Temple, 1965; M.A., 1967; Ph.D., Florida State, 1971.

Josef M. Brozek (1959, 1963)
Research Professor of Psychology
Ph.D., Charles (Prague), 1937.

Arthur William Brune (1952, 1971)
Associate Professor of Civil Engineering
B.S. in E.M., Missouri School of Mines, 1941; M.S. in E.M., 1946; Ph.D., Penn State, 1952. P.E., Pennsylvania, 1957.

John Joseph Burbridge, Jr. (1962, 1964)
Instructor in Industrial Engineering
B.S., Lehigh, 1962; M.S., 1964.

Sidney R. Butler (1969)
Associate Professor of Metallurgy and Materials Science
B.S., Maine, 1954; M.S., Penn State, 1956; Ph.D., 1960.

Ann Cali (1972)
Assistant Professor of Biology
B.S., Florida, 1964; M.S., Ohio State, 1966; Ph.D., 1970.

Clarence Bowen Campbell (1955, 1966)
Dean of Residence
B.A., Temple, 1937; M.A., Lehigh, 1947.

Biruta Cap (1969)
Assistant Professor of French, Modern Foreign Languages and Literatures
B.A., Connecticut, 1960; M.A., Rutgers, 1961; Ph.D., 1968.

Bobb Carson (1971)
Assistant Professor of Geology
B.A., Carleton College, 1965; M.S., Washington, 1967; Ph.D., 1971.

Alfred Joseph Castaldi (1964, 1972)
Professor of Education and Director, Division of Elementary Education, School of Education
B.S., Penn, 1951; M.S., 1956; Ed.D., 1964.

Edward Charles (1969)
Instructor in Education
B.A., Bluffton, 1953; LL.B., Rutgers, 1953; M.A., Temple, 1961; Ed.D., Lehigh, 1970.

Marvin Charles (1970)
Assistant Professor of Chemical Engineering
B.S., Brooklyn Polytechnic, 1964; M.S., 1967; Ph.D., 1970.

John McIlvain Cheezum, Jr. (1964, 1972)
Fiscal Associate, Office of Research
A.B., Penn, 1964.

John C. Chen (1970)
Professor of Mechanical Engineering and Mechanics
B.Ch.E., Cooper Union, 1956; M.S., Carnegie-Mellon, 1959; Ph.D., Michigan, 1961.

Tony E. P. Chen (1972)
Assistant Professor of Mechanics
B.S., National Chung-hsing University (Taiwan), 1966: M.S., Lehigh, 1969; Ph.D., 1972.

Wai-Fah Chen (1966, 1971)
Associate Professor of Civil Engineering
B.S., Cheng-Kung University, 1959; M.S., Lehigh, 1963; Ph.D., Brown, 1966.

Chang-Shuei Cheng (1965)
Instructor in Physics
B.S., National Taiwan University, 1958; M.S., National Tsing Hua University, 1960; Ph.D., Lehigh, 1968.

Thomas C. Cheng (1969, 1970)
Professor of Biology and Director, Center for Health Sciences and Institute for Pathobiology
A.B., Wayne State, 1952; M.S., Virginia, 1956; Ph.D., 1958.

Ye T. Chou (1968, 1970)
Professor of Metallurgy and Materials Science
B.S., Chungking University, 1945; M.S., Carnegie-Mellon, 1954; Ph.D., 1957.

Glenn James Christensen (1939, 1969)
University Distinguished Professor
B.A., Wooster, 1935; Ph.D., Yale, 1939; LL.D., College of Notre Dame (Md.), 1966.

Stuart R. Christie (1971)
Assistant to the Director of Development
B.A., Washington and Jefferson, 1969.

Maria C. Chun (1969)
Postdoctoral Research Assistant in Chemistry
B.S., Manila University (Philippines), 1965; Ph.D., Penn State, 1969.

Charles K. Clarke (1969)
Instructor in Metallurgy and Materials Science
B.S., Alabama, 1968.

Curtis William Clump (1955, 1960)
Professor of Chemical Engineering
B.S., Bucknell, 1947; M.S., 1949; Ph.D., Carnegie-Mellon, 1954.

Alvin Cohen (1962, 1970)
Professor of Economics
B.A., George Washington, 1953; M.B.A., Columbia, 1955; Florida, 1962.

Robert Carlton Cole (1964, 1972)
Assistant Professor of English
A.B., Marshall, 1959; M.A., Wake Forest, 1964; Ph.D., Lehigh, 1971.

Frank Thomas Colon (1965, 1967)
Associate Professor of Government
A.B., Geneva College, 1954; M.A., Pittsburgh, 1960; Ph.D., 1963.

Mary A. Conahan (1971)
Assistant Professor of Education
B.A., Penn State, 1949; E.D., Lehigh, 1971

George Powell Conard II (1952, 1960)
Professor and Chairman of Metallurgy and Materials Science
B.S., Brown, 1941; M.S., Stevens Institute, 1948; Sc.D., M.I.T., 1952.

Janet Donna Connor (1971)
Assistant to the Director, Public Information
B.A., Moravian, 1969; M.A., Rutgers, 1971.

Samuel Irvin Connor (1961)
Director of Public Information
B.A., Lehigh, 1949.

Robert William Coughlin (1965, 1971)
Professor of Chemical Engineering
B.S., Fordham, 1956; Ph.D., Cornell, 1961. P.E., New Jersey, 1964.

John Nelson Covert (1967)
Assistant Professor of Physical Education, Varsity Cross Country and Track Coach
B.S.Ed., Buffalo State, 1953.

Raymond Gibson Cowherd (1956, 1963)
Professor of History
A.B., William Jewell, 1933; M.A., Penn, 1936; Ph.D., 1940.

Edward J. Crawford (1972)
Instructor in Education, Centennial School
B.A., Lehigh, 1971; M.Ed., Syracuse, 1972.

Cloyd Criswell (1947, 1971)
Associate Professor of English
B.S. in Ed., Millersville State, 1933; M.A., New York, 1937.

Robert Benjamin Cutler, (1954, 1962)
Professor and Chairman of Music, University Organist
A.B., Bucknell, 1934; M.A., Columbia, 1935.

Walter Emil Dahlke (1964)
Professor of Electrical Engineering
Diploma, University of Berlin; Ph.D., 1936; Ph.D. (habil), University of Jena, 1939.

George F. Dalton (1970)
Executive Director, Institute for the Development of Riverine and Estuarine Systems
B.S., United States Naval Academy, 1938.

John Hartley Daniels (1964, 1970)
Associate Professor in Civil Engineering
B.S., University of Alberta (Canada), 1955; M.S., Illinois, 1959; Ph.D., Lehigh, 1967. P.E., Alberta, Canada, 1955.

Joseph F. Dannenfelser (1971)
Assistant Professor of Military Science
B.S., Loyola College, 1967. Captain, U.S. Army.

Paul L. Davis (1969)
Assistant Professor of Mathematics
A.B., West Virginia, 1962; M.S., 1962; Ph.D., Carnegie-Mellon, 1969.

Warren B. Davis (1971)
Associate Professor of Education
A.B., Ohio, 1933; M.A., Ohio State, 1939; Ph.D., 1952.

Edna Sophia DeAngeli (1963, 1970)
Associate Professor of Classics
B.S., Temple, 1938; M.A., Penn, 1960; Ph.D., 1965.

Jack Angelo DeBellis (1964, 1969)
Associate Professor of English
A.B., Florida, 1957; A.M., U.C.L.A., 1959; Ph.D., 1964.

Dorothy Delp (1971)
Nurse, Health Service
R.N., St. Luke's Hospital, 1946.

Margaret Linn Dennis (1953, 1968)
Assistant Librarian, Readers' Service
A.B., Allegheny, 1939; B.S. in L.S., Syracuse, 1940.

Jacob De Rooy (1967, 1969)
Assistant Professor of Economics
A.B., Rutgers, 1963; A.M., 1965; Ph.D., 1969.

Alfred James Diefenderfer (1961, 1965)
Associate Professor of Chemistry
B.S., Pittsburgh, 1957; Ph.D., M.I.T., 1961.

Dennis Roby Diehl, (1972)
Assistant to the Executive Director, Alumni Association
B.S., Lehigh, 1970; M.B.A., 1971.

Doris Dillman (1970)
Assistant to the Dean, Graduate School

Ernest Nevin Dilworth (1949, 1967)
Professor of English
Ph.B., Kenyon, 1933; M.A., Pittsburgh, 1937; Ph.D., Columbia, 1948.

Andrew D. Dimargonas (1972)
Associate Professor of Mechanical Engineering
Mechanical Engineer, Athens National University of Technology, 1961; Ph.D., Rensselaer, 1970.

George Anson Dinsmore (1955, 1967)
Associate Professor of Civil Engineering
B.E., Yale, 1946; M.S., Colorado, 1955.

Thomas L. Dinsmore (1965, 1967)
Administrator, Metallurgy and Materials Science
B.S., Rochester, 1946; M.S., Princeton, 1948.

Harry A. Dower (1970)
Adjunct Professor of Law
A.B., Lafayette, 1940; L.L.B., Yale, 1948.

Joseph Albert Dowling (1958, 1967)
Professor of History
A.B., Lincoln Memorial, 1948; M.A., New York, 1951; Ph.D., 1958.

George Clarence Driscoll, Jr. (1950, 1965)
Professor of Civil Engineering; Associate Director, Fritz Engineering Laboratory
B.S. in C.E., Rutgers, 1950; M.S., Lehigh, 1952; Ph.D., 1958. P.E., Pennsylvania, 1969.

Glenny Dunbar (1972)
Instructor in Education
A.A., Finch, 1965; B.A., Boston, 1967; M.A., Fordham, 1972.

Aurie Nichols Dunlap (1948, 1972)
Professor of International Relations
A.B., Union (New York), 1929; A.M., Columbia, 1931; Ph.D., 1955.

Frederick Homer Dunlap (1965)
Assistant Professor of Physical Education, Varsity Head Football Coach
B.A., Colgate, 1950.

Deborah J. Dwyer (1971)
Assistant to the Director of Undergraduate Financial Aid
A.A., Green Mountain, 1967; B.S., Springfield (Mass.), 1969.

Nikolai Eberhardt (1962, 1970)
Professor of Electrical Engineering
Dipl. Engr., University of Munich, 1957; Ph.D., 1962.

Evelyn Strawn Eberman (1955, 1972)
Assistant Director of Residence Halls
B.A., Swarthmore, 1921.

Arthur Roy Eckardt (1951, 1956)
Professor and Chairman of Religion Studies
B.A., Brooklyn, 1942; B.D., Yale, 1944; Ph.D., Columbia, 1947; L.H.D., Hebrew Union College, Jewish Institute of Religion, 1969.

Dominic G. B. Edelen (1969)
Professor, Center for the Application of Mathematics
B.E.S., Johns Hopkins, 1954; M.S.E., 1956; Ph.D., 1965.

Andrew J. Edmiston (1967)
Professor of Education, Director, Counseling Service
A.B., West Virginia, 1951; M.S., Miami, 1953; Ph.D., Penn State, 1960.

Bennett Eisenberg (1972)
Assistant Professor of Mathematics
A.B., Dartmouth, 1964; Ph.D., M.I.T., 1968.

Mohammed S. El-Aasser (1972)
Research Associate, Center for Surface and Coatings Research
B.S., Alexandria U. (Egypt), 1962; M.S., 1966; Ph.D., McGill, 1972.

Jonathan Britton Elkus (1957, 1965)
Professor of Music
B.A., Berkeley, 1953; M.A., Stanford, 1954.

George Mark Ellis (1967)
Assistant Dean, College of Arts and Science, and Associate Professor of History
A.B., Yale, 1943; A.M., Harvard, 1947; Ph.D., 1952.

John H. Ellis (1971)
Associate Professor of History
B.S., Memphis State, 1955; M.A., 1957; Ph.D., Tulane, 1962.

John Stuart Ellison (1970)
Assistant Professor of Military Science
B.S., Illinois, 1964. Captain, U.S. Army.

Raymond Jay Emrich (1946, 1958)
Professor of Physics
A.B., Princeton, 1938; Ph.D., 1946.

James Vandeusen Eppes (1950, 1972)
Professor of Mechanical Engineering
B.A., Virginia, 1928; M.E., Cornell, 1931; M.S. in M.E., Lehigh, 1943.

Fazil Erdogan (1952, 1963)
Professor of Mechanics
Yuk. Muh., Technical Institute of Istanbul, 1948; Ph.D., Lehigh, 1955.

F. Laird Evans (1969)
Instructor in Centennial School
B.A., Penn State, 1966; M.Ed., Lehigh, 1969.

Hsia-Yang Fang (1966, 1969)
Associate Professor of Civil Engineering
B.S., Hangchow University, 1947; M.S., Purdue, 1956; Ph.D., West Virginia, 1966.

Douglas David Feaver (1956, 1966)
Professor of Classics
B.A., Toronto, 1948; M.A., Johns Hopkins, 1949; Ph.D., 1951.

Frank Joseph Feigl (1967, 1970)
Associate Professor of Physics
A.B., Notre Dame, 1958; Ph.D., University of Pittsburgh, 1965.

Jacqueline Marie Fetsko (1949, 1966)
Administrative Assistant, Center for Surface and Coatings Research
B.A., Penn, 1946; M.S., Lehigh, 1953.

Barry J. Fetterman (1968)
Instructor in Physical Education
B.S., Delaware, 1963.

Patricia A. Finady (1971)
Administrative Assistant, Counseling
B.A., Moravian, 1965.

William J. Fincke, Jr. (1972)
Social Sciences Cataloger
B.A., New York at Oneonta, 1970; M.L.S., New York at Albany, 1971.

John William Fisher (1961, 1969)
Professor of Civil Engineering and Associate Director, Fritz Engineering Laboratory
B.S., Washington, 1956; M.S., Lehigh, 1958; Ph.D., 1964. P.E., Illinois, 1960.

Richard B. Fisher (1970)
Assistant Director of Placement and Personnel Services
B.A., Moravian, 1966; M.A., Lehigh, 1970.

Thomas Fleck, Jr. (1965, 1970)
Assistant Professor of Education and Principal, Centennial School
B.S., West Chester, 1956; M.Ed., Temple, 1960.; Ed.D., Lehigh, 1970.

Catherine L. Flecksteiner (1945, 1965)
Serials Cataloger

Hubert L. Flesher (1971)
Chaplain and Assistant Professor of Religion Studies
B.A., Pomona College, 1954; B.D., Yale, 1958; M.A., 1961.

Robert Thomas Folk (1961, 1966)
Professor of Physics
B.S., in E.E., Lehigh, 1953; B.S., in Phys., 1954; M.S., 1955; Ph.D., 1958.

Lou V. Forcum (1971)
Assistant Bursar

Roy Foster (1967)
Assistant Director, Public Information
A.B., Ursinus, 1951.

Alan Shivers Foust (1952, 1965)
McCann Professor of Chemical Engineering
B.S., Texas, 1928; M.S., 1930; Ph.D., Michigan, 1938. P.E., Michigan, 1947.

Frederick Mayhew Fowkes (1968)
Professor and Chairman of Chemistry
B.S., University of Chicago, 1936; Ph.D., 1938.

Wyman Beall Fowler, Jr. (1966, 1969)
Professor of Physics
B.S., Lehigh, 1959; Ph.D., Rochester, 1963.

James Richard Frakes (1958, 1967)
Professor of English
B.A., Penn State, 1948; M.A., Chicago, 1949; Ph.D., Penn, 1953.

Barbara Brown Frankel (1973)
Instructor in Cultural Anthropology
Ph.B., Chicago, 1947; B.A., Goddard, 1966; M.A., Temple, 1970; M.A., Princeton, 1971.

Catherine Franklin (1959, 1971)
Director of Central Copying and Mailing

Paul Justus Franz, Jr. (1944, 1962)
Vice President–Development
B.S. in Bus. Adm., Lehigh, 1944; M.A., 1955.

John A. Fratto (1972)
Assistant Professor of Aerospace Studies
B.A., Fairmount State, 1967; M.B.A., Missouri, 1972. Captain, U.S.A.F.

Bruce Dale Fritchman (1969, 1972)
Associate Professor of Electrical Engineering
B.S., Lehigh, 1960; E.P., 1961; M.S., 1963; Ph.D., 1967.

Matthew W. Gaffney (1971)
Associate Professor of Education
A.B., Hobart, 1935; M.A., Rochester, 1941; Ed.D., Buffalo, 1953.

Linda Galda (1971)
Assistant Operations Supervisor of Administrative Systems
B.A., Rider, 1969.

Edward J. Gallagher (1969, 1970)
Assistant Professor of English
B.S., St. Joseph's, 1964; Ph.D., Notre Dame, 1970.

Robert Taylor Gallagher (1942, 1964)
Professor of Mining Engineering; Associate Dean, College of Engineering
B.S. in E.M., Penn State, 1927; M.A., in Geol., Missouri, 1938; D.E.M., Colorado School of Mines, 1941. P.E., Pennsylvania, 1945; New Jersey, 1955.

Gerald Garb (1967)
Professor of Economics
B.S., Penn, 1948; M.A., Berkeley, 1951; Ph.D., 1957.

Arthur Parcel Gardner (1958, 1966)
Associate Professor of German, Modern Foreign Languages and Literatures
A.B., Duke, 1944; A.M., Harvard, 1945; Ph.D., 1950.

Duncan Buchanan Gardiner, Jr. (1972)
Instructor in Russian, Modern Foreign Languages and Literatures
B.A., Miami of Ohio, 1961; M.A., Indiana, 1965.

J. Bruce Gardiner (1972)
Head Swimming Coach, and Assistant Director of Intramurals and Recreation
B.S., Springfield, 1968; M.Sc., 1972.

Dermot M. Garrett (1973)
Instructor in Education
B.Sc.Ed., Christ's College (Liverpool, England), 1970.

James J. Garrigan (1972)
Instructor in Education
A.B., Seton Hall, 1963; M.A., 1965.

Juraj Gebauer (1969)
Postdoctoral Research Associate in Chemical Engineering
M.S., Komensky University (Bratislava), 1958; Slovak Academy of Sciences, 1965.

Jacob Myer Geist (1959)
Lecturer in Chemical Engineering
B.S., Purdue, 1940; M.S., Penn State, 1942; Ph.D., Michigan, 1950.

Bhaskar Kumar Ghosh (1961, 1968)
Professor of Mathematics
B.Sc., Calcutta (India), 1955; Ph.D., London, 1959.

Thomas de Magnin Gilburg (1971)
Assistant Varsity Football Coach and Varsity Lacrosse Coach
B.A., Syracuse, 1961.

Jerome J. Gillen (1973)
Adjunct Assistant Professor of History
A.B., St. Peter's (New Jersey), 1956; M.A., 1968; Ph.D., Lehigh, 1972.

Frederick Robert Gladeck (1966)
Instructor in International Relations
B.A., Lehigh, 1960; M.A., Penn, 1964.

Elmer William Glick (1949, 1972)
Vice President and Treasurer
B.A., Lehigh, 1933.

William Monroe Glose III (1960, 1967)
Accountant
B.S. in Bus. Adm., Lehigh, 1958.

Lawrence D. Glueck (1971)
Assistant Football Coach
B.S., Villanova, 1963; B.A., 1970.

Hans Rueniger Gnerlich (1967, 1969)
Instructor in Electrical Engineering
Dipl. Ing., Technical University (Karlsruhe), 1967; M.S., Lehigh, 1969.

Joseph I. Goldstein (1968, 1970)
Associate Professor of Metallurgy and Materials Science
B.S., M.I.T., 1960; S.M., 1962; Sc.D., 1964.

Arthur Freeman Gould (1947, 1953)
Professor and Chairman of Industrial Engineering
S.B., M.I.T., 1938; M.S., Lehigh, 1949. P.E., Pennsylvania, 1949.

Christa V. Graf (1970)
Adjunct Assistant Professor of History
B.A., Berkeley, 1962; M.A., Cornell, 1965; Ph.D., 1970.

Walter H. Graf (1968)
Associate Professor of Civil Engineering
Dipl. Ing., University of Vienna (Austria), 1959; Ph.D., Berkeley, 1963.

Margaret C. Grandovic (1962, 1969)
Assistant Professor of Education
B.S., Temple, 1938; M.Ed., 1957; Ed.D., 1968.

Marguerite B. Gravez (1957, 1971)
Lecturer in Mathematics
B.A., Hunter, 1950; M.A., Radcliffe, 1951.

James Sproat Green V (1966, 1969)
Assistant Professor of Information Science
B.A., Lehigh, 1966; M.A., 1968; Ph.D., 1969.

David Mason Greene (1958, 1964)
Professor of English
B.A., San Diego State, 1951; M.A., Berkeley, 1952; Ph.D., 1958.

James A. Greenleaf (1970)
Instructor in Management and Finance
B.S., Penn State, 1964; M.S., Lehigh, 1966.

Mikell Porter Groover (1966, 1969)
Assistant Professor of Industrial Engineering
B.A., Lehigh, 1961; B.S., 1962; M.S., 1966; Ph.D., 1969.

Charles Guditus (1964, 1968)
Professor of Education and Director, Division of Educational Administration, School of Education
B.S., Penn State, 1950; M.S., Bucknell, 1952; Ed.D., Lehigh, 1965.

Samuel Linial Gulden (1953, 1967)
Associate Professor of Mathematics
B.S., City College of New York, 1949; M.A., Princeton, 1950.

Gopal D. Gupta (1972)
Assistant Professor of Mechanical Engineering
B.Tech., Indian Institute of Technology (Kanpur, India), 1967; M.S., Lehigh, 1968; Ph.D., 1970.

Clark W. Hahn (1967)
Assistant Accountant
B.A., Muhlenberg, 1972.

Walter Charles Hahn, Jr. (1963, 1972)
Professor of Metallurgy and Materials Science and Program Manager, Institute for Metal Forming
B.S., Lafayette, 1952; M.S., Penn State, 1958; Ph.D., 1960.

John McVickar Haight, Jr. (1949, 1967)
Professor of History
A.B., Princeton, 1940; M.A., Yale, 1947; Ph.D., Northwestern, 1953.

Theodore Hailperin (1946, 1961)
Professor of Mathematics
B.S., Michigan, 1939; Ph.D., Cornell, 1943.

James W. Harper (1971)
Director, Community Relations
B.S., Northwestern, 1954; M.S., 1956.

Nathan Walter Harris (1970)
Assistant Dean of Student Life
B.A., Lincoln University, 1965.

Robert Richard Harson (1966)
Assistant Professor of English
B.A., Wagner, 1963; M.A., Ohio, 1964; Ph.D., 1966.

Ronald John Hartranft (1966, 1972)
Associate Professor of Mechanics
B.S., Lehigh, 1963; M.S., 1964; Ph.D., 1966.

Miloslav Hartman (1969)
Postdoctoral Research Associate in Chemical Engineering
M.S., Technical University (Prague), 1960; Ph.D., Czech Academy of Science (Prague), 1965.

Albert Edward Hartung (1947, 1968)
Professor and Chairman of English
B.A., Lehigh, 1947; M.A., 1949; Ph.D., 1957.

D. P. H. Hasselman (1970)
Associate Professor of Metallurgy and Materials Science
B.Sc., Queen's University, 1957; M.A., Sc., University of British Columbia, 1960; Ph.D., Berkeley, 1966.

Emil Andrew Havach (1941, 1949)
Head Trainer
D. Surg. Chirop., Temple, 1936.

Michael P. Hayes (1968)
Visiting Associate Professor in Center for Application of Mathematics
B.Sc., University College (Galway), 1956; M.Sc., 1957; Ph.D.

Thomas Morris Haynes (1952, 1969)
Professor of Philosophy and Director, Freshman Seminars
A.B., Butler, 1941; M.A., Illinois, 1949; Ph.D., 1949.

Leroy Arlan Heckman (1967)
Assistant Professor of Physical Education and Varsity Basketball Coach
B.S. Ed., Kutztown State, 1949; M.A., Colorado State, 1961.

Stanley Frederick Heffner (1930, 1946)
Manager, Bookstore

Ned D. Heindel (1966, 1969)
Associate Professor of Chemistry and Director, Division of Biological Chemistry and Biophysics, Center for Health Sciences
B.S., Lebanon Valley, 1959; M.S., Delaware, 1961; Ph.D., 1963.

Sidney Samuel Herman (1962, 1971)
Professor of Biology and Director, South Jersey Wetlands Institute
B.S., Georgetown, 1953; M.S., Rhode Island, 1958; Ph.D., 1962.

Roy Cecil Herrenkohl, Jr. (1966, 1969)
Associate Professor of Social Psychology and Methodology and Director, Behavioral Science Program, Center for Social Research
B.A., Washington & Lee, 1954; Ph.D., N.Y.U., 1966.

Richard Warren Hertzberg (1964, 1968)
Associate Professor of Metallurgy and Materials Science
B.S., City College of New York, 1960; M.S., M.I.T., 1961; Ph.D., Lehigh, 1965.

Anna Pirscenok Herz (1966, 1972)
Professor of Russian and Chairman of Modern Foreign Languages and Literatures
B.S., Penn, 1949; M.A., 1950; M.A., Columbia, 1951; Ph.D., Penn, 1956.

Gail Chadwell Herz (1972)
Lecturer in Mathematics
B.S., Nevada, 1964; M.S., Lehigh, 1970; Ph.D., 1972.

Leon Nathaniel Hicks, Jr. (1970)
Assistant Professor of Fine Arts
B.S., Kansas State, 1959; M.A., M.F.A., Iowa, 1963.

Frank H. Hielscher (1971)
Assistant Professor of Electrical Engineering
B.S., Drexel, 1961; M.S., Denver, 1963; Ph.D., Illinois, 1966.

Mary Joanne Hill (1967)
Editorial Associate, Office of Research
B.S., Carnegie-Mellon, 1959; M.A., Pittsburgh, 1964.

Donald John Hillman (1960, 1964)
Professor and Chairman of Philosophy and Director, Center for Information Science
B.A., Cambridge (England), 1955; M.A., 1959; M.Litt., 1962.

Peter Daniel Hilton (1969)
Assistant Professor of Mechanical Engineering and Mechanics
B.S., Lehigh, 1965; M.S., Harvard, 1966; Ph.D., 1969.

Terence John Hirst (1968, 1972)
Assistant Professor of Civil Engineering and Associate Director, Marine Geotechnical Laboratory
B.A.S., University of British Columbia, 1962; M.A.S., 1966; Ph.D., Berkeley, 1968.

James B. Hobbs (1966, 1970)
Professor of Management and Accounting and Chairman of Management and Finance
A.B., Harvard, 1952; M.B.A., Kansas, 1957; D.B.A., Indiana, 1962.

Wayne Hoffman (1968, 1973)
Assistant Director, Administrative Systems Office

Frank Holcombe (1969)
Postdoctoral Fellow in Chemistry
B.S., Old Dominion College, 1964.

Robert Mark Holcombe (1963, 1968)
Director of Development
B.S., Lehigh, 1958; M.S., 1969.

William Fowler Hollabaugh (1960, 1972)
Manager of Systems Programming, Computing Center
B.S., Lehigh, 1959; M.S., 1960; Ph.D., 1966.

Joseph P. Holzer (1970)
Administrative Assistant, Computing Center

Carl Sanford Holzinger (1959, 1968)
Associate Professor of Electrical Engineering
B.S., Lehigh, 1956; M.S., 1957; Ph.D., 1963.

Frank Scott Hook (1952, 1965)
Professor of English
A.B., Missouri, 1942; M.A., 1947; Ph.D., Yale, 1952.

Ronald F. Horvath (1972)
Assistant Planner, Campus Planning Office
B.A., Lehigh, 1972.

David D. Hott (1971)
Instructor in Industrial Engineering
B.S., Salem, 1964; M.S., Pittsburgh, 1967; M.S., N.Y.U., 1971.

Lynne H. Hott (1971)
Instructor in Industrial Engineering
B.S., Pittsburgh, 1967; M.S., Stevens Institute, 1970.

Richard Hsia (1969)
Postdoctoral Fellow in Chemistry
B.S., Cheng Kung University (Taiwan), 1963; Ph.D., McGill University (Canada), 1969.

Chuan-Chih Hsiung (1952, 1960)
Professor of Mathematics
B.S., National Chekiang (China), 1936; Ph.D., Michigan State, 1948.

Ti Huang (1967)
Associate Professor of Civil Engineering
B.S., Tangshan Engineering College, 1948; M.S., Michigan, 1952; Ph.D., 1960.

John Joseph Huber (1968)
Assistant Professor of Military Science
B.A., Pennsylvania Military College, 1963. Major, Transportation Corps, U.S. Army.

Volker Huelck (1968)
Research Associate in Chemical Engineering
B.S., University of Karlsruhe (Germany), 1967.

Matthew H. Hulbert (1969)
Assistant Professor of Chemistry
B.S., Washington & Lee, 1964; M.S. Wisconsin, 1967; Ph.D., 1969.

John W. Hunt (1972)
Dean of the College of Arts and Science and Professor of English
B.A., Oklahoma, 1949; B.D., 1952; Ph.D., Chicago, 1961.

Ruth A. Hurley (1971)
Associate Dean of Student Life
B.A., New Hampshire, 1963; M.S., Indiana, 1966.

Allen E. Hye (1973)
Assistant Professor of German, Modern Foreign Languages and Literatures
B.A., Franklin and Marshall, 1966; M.A., Middlebury, 1967; Ph.D., Connecticut, 1972.

Donald Gary Ingalls (1969)
Electronics Specialist, Center for Marine and Environmental Studies

Jon Terence Innes (1965, 1968)
Assistant Professor of Economics
B.S., Penn State, 1958; M.A., Oregon, 1961; Ph.D., 1967.

George Irwin (1967)
Faculty Associate, Fritz Lab
A.B., Knox College, 1930; M.S., Illinois, 1933; Ph.D., 1937.

George John Jackson (1972)
Adjunct Professor of Biology
B.A., Chicago, 1952; M.S., 1954; Ph.D., 1958.

Thomas Edgar Jackson (1937, 1969)
Professor of Mechanical Engineering
B.S., Carnegie-Mellon, 1934; M.S., Lehigh, 1937. P.E., Pennsylvania, 1946.

Eustace Anthony James (1962, 1972)
Associate Professor of English
A.B., Princeton, 1958; M.A., Pennsylvania, 1960; Ph.D., 1965.

M. M. P. Janssen (1967)
Research Associate in Chemistry
M.S., Technological University Eindhoven (Netherlands), 1960; Chemistry Engineering, 1963; Ph.D., Technological Sciences, 1966.

George Robert Jenkins (1948, 1963)
Director of the Office of Research and Professor of Geology
B.A., Colorado, 1936; Ph.M., Wisconsin, 1938.

Finn Bjorn Jensen (1947, 1954)
MacFarlane Professor in Theoretical Economics and Chairman of Economics
A.B., Southern California, 1934; M.A., 1935; Ph.D., 1940.

Robert Leroy Johnson (1970, 1972)
Associate Professor of Civil Engineering and Director, Environmental Engineering Laboratory, CMES
B.S., Iowa State, 1957; M.S., 1963; Ph.D., 1969. P.E., Iowa.

Robert W. Johnson (1969)
Assistant Professor of Mathematics
A.B., Columbia, 1962; M.S., City University of New York, 1965; Ph.D., 1969.

Colin E. Jones (1970)
Assistant Professor of Physics
B.S., Carnegie-Mellon, 1963; M.S., Illinois, 1965; Ph.D., 1970.

Reese D. Jones (1969)
Adjunct Professor of Economics
B.S., Wilkes, 1955; M.S., Penn, 1957.

Robert Griffith Jones (1965, 1969)
Associate Professor of Social Psychology
A.B., Davidson, 1958; B.D., Yale, 1961; Ph.D., Duke, 1966.

Carey Bonthron Joynt (1951, 1960)
Professor and Chairman of International Relations
B.A., Western Ontario, 1945; M.A., 1948; Ph.D., Clark, 1951.

Safeta Sophie Juka (1972)
Assistant Professor of French, Modern Foreign Languages and Literatures
Lic. Litt., Sorbonne, 1950; Dr. d'Univ., 1969.

Arturs Kalnins (1965, 1967)
Professor of Mechanics and Director, Division of Bioengineering, Center for Health Sciences
B.S., Michigan, 1955; M.S., 1956; Ph.D., 1960.

George Eugene Kane (1950, 1964)
Professor of Industrial Engineering
B.S., Penn State, 1948; M.S., Lehigh, 1954. P.E., Pennsylvania, 1955.

Alvin Sheldon Kanofsky (1967, 1971)
Associate Professor of Physics
B.A., Penn, 1961; M.S., 1962; Ph.D., 1966.

John J. Karakash (1946, 1966)
Distinguished Professor and Dean, College of Engineering
B.S., Duke, 1937; M.S., Penn, 1938. P.E., Pennsylvania, 1948.

Andrew James Kasarda (1968, 1971)
Associate Professor of Information Sciences, and Associate Director, Center for Information Science
B.A., Penn State, 1962; M.S., Lehigh, 1966; Ph.D., 1968.

Marshall L. Kaufman (1972)
Assistant Professor of English and Technical Director of Special University Events
B.A., Bridgeport, 1969; M.A., Trinity at San Antonio, 1972.

Edwin J. Kay (1971)
Assistant Professor of Psychology
B.S., Rensselaer, 1964; M.S., Lehigh, 1966; Ph.D. (mathematics), 1968; Ph.D. (psychology), 1972.

Yakovos Kazakia (1972)
Research Associate, Center for the Application of Mathematics
M.Sc., Istanbul Technological University, 1968; Ph.D., Lehigh, 1972.

John Daniel Keefe (1965, 1971)
Assistant Professor of Economics
B.S., Lehigh, 1948; M.A., Miami (Florida), 1955.

C. Merris Keen, Jr. (1967)
Manager, Fraternity Services
B.S., Lehigh, 1948.

William E. Keim (1967)
Lecturer in Education
B.S., Millersville State, 1949; M.A., 1953; D.Ed., 1956.

Elsie L. Kellerman (1966)
Research Associate, Center for Surface and Coatings Research
A.B., Mt. Holyoke, 1959; Ph.D., Penn, 1963.

Richard Kellerman (1967)
Research Associate, Center for Surface and Coatings Research
B.S., Manchester (England), 1966; Ph.D., Lehigh, 1972.

John L. Kemmerer (1966)
Assistant Purchasing Agent

Kathleen A. Kemmerle (1970)
Systems Programmer, Administrative Systems Office
B.S., Moravian, 1969.

Joseph P. Kender (1968, 1971)
Associate Professor of Education
A.B., Mt. St. Mary's College, 1952; M.A., Villanova, 1955; Ed.D., Penn, 1967.

Robert W. Kennedy (1968)
Instructor in Physical Education
B.S., West Virginia, 1962.

Samir Anton Khabbaz (1960, 1968)
Professor of Mathematics
B.A., Bethel, 1954; M.A., Kansas, 1956; Ph.D., 1960.

Frank J. Kidder III (1972)
Instructor in Education
B.S., Ursinus, 1969; M.Ed., Lehigh, 1971.

Yong Wook Kim (1968)
Assistant Professor of Physics
B.S., Seoul National University, 1960; M.S., 1962; Ph.D., Michigan, 1968.

Jerry Porter King (1962, 1968)
Professor of Mathematics
B.S., Kentucky, 1958; M.S., 1959; Ph.D., 1962.

Marlin Eugene Kipp (1972)
Instructor in Mechanics
B.S., Lehigh, 1967; M.S., 1968.

Charles Edward Klatt (1969)
Assistant Professor of Military Science
B.S., Michigan, 1963. Captain, U.S. Army.

Lynn Dianne Klein (1970)
Production Assistant, University Publications
B.A., Muhlenberg, 1970.

Mary R. Kleinginna (1972)
Instructor in Education
B.A., Wilkes, 1963; M.S.Ed., Temple, 1971.

Kamil Klier (1967, 1968)
Associate Professor of Chemistry
B.S., Chemico-Technological University (Prague), 1954.

Alfred Paul Koch (1946, 1961)
Professor of Accounting
B.S., Bloomsburg State, 1939; M.S., Bucknell, 1940. C.P.A., Pennsylvania, 1952.

Winfred Kohls (1969)
Adjunct Professor of History
B.A., Augustana, 1951; M.A., California at Berkeley, 1959; Ph.D., 1967.

Celal Nizamettin Kostem (1966, 1972)
Associate Professor of Civil Engineering
B.S., Technical University of Istanbul, 1960; M.S., 1961; Ph.D., Arizona, 1966.

Ralph Wayne Kraft (1962, 1965)
New Jersey Zinc Professor of Metallurgy and Materials Science
B.S., Lehigh, 1948; M.S., Michigan, 1956; Ph.D., 1958.

Charles Stephen Kraihanzel (1962, 1970)
Professor of Chemistry
Sc.B., Brown, 1957; M.S., Wisconsin, 1959; Ph.D., 1962.

Paul F. Kram (1971)
Instructor, School of Education
B.A., Moravian, 1965; M.A., Lehigh, 1967.

Gretchen A. Krasley (1970)
Instructor in Education
B.A., Muhlenberg, 1968; M.Ed., Lehigh, 1970.

Michael R. Krasley (1971)
Instructor in Education
B.S., Moravian, 1965.

George Krauss, Jr. (1963, 1972)
Professor of Metallurgy and Materials Science
B.S., Lehigh, 1955; M.S., M.I.T., 1958; Sc.D., 1961.

Steven Krawiec (1970)
Assistant Professor of Biology
A.B., Brown, 1963; Ph.D., Yale, 1968.

Philip L. Kreider (1970)
Acting Director, University Health Service
A.B., Dartmouth, 1953; M.D., Temple, 1957.

Joseph R. Kress (1971)
Instructor in Military Science
MSG, U.S. Army

Leon Elwood Krouse (1951, 1963)
Associate Professor of Finance
B.A., Susquehanna, 1941; M.S., Bucknell, 1947; Ph.D., New York, 1958.

John Milton Kulicki (1971)
Instructor in Civil Engineering
B.A., Lafayette, 1965; M.S., Lehigh, 1967.

Donald H. Kunkel (1971)
Associate Professor of Military Science
B.S., St. Peter's (New Jersey), 1960. Major, U.S. Army.

Ella Jane Kunkle (1971)
Instructor in Education
B.A., Fairleigh Dickinson, 1963.

Albert Barry Kunz (1962, 1968)
Research Associate in Physics
B.S., Muhlenberg, 1962; M.S., Lehigh, 1964; Ph.D., 1966.

Anastasios Kydoniefs (1969)
Assistant Professor, Center for the Application of Mathematics
B.Sc., Athens (Greece), 1963; M.Sc., Nottingham (England 1965; Ph.D., 1967.

Jay C. Lacke (1969)
Instructor in Marketing
B.A., Lehigh, 1964; M.B.A., Columbia, 1966.

Gary Bernard Laison (1961, 1970)
Assistant Professor of Mathematics
B.A., Penn, 1958; M.A., 1960; Ph.D., 1969.

Eugene M. Landis (1967)
Adjunct Professor of Biology
B.S., Penn, 1922; M.S., 1924; M.D., 1926; Ph.D., 1927; M.S. (Hon.), Yale 1938.

John D. Landis (1967, 1971)
Assistant Professor of Industrial Engineering
B.S., Lehigh, 1965; M.S., 1967; Ph.D., 1971.

Nicholas Anthony Lapara (1964, 1970)
Assistant Professor of Philosophy
B.S., Lehigh, 1959; B.A., 1961; M.A., Pittsburgh, 1962; Ph.D., 1970.

Arthur Irving Larky (1954, 1964)
Professor of Electrical Engineering
B.S., Lehigh, 1952; M.S., Princeton, 1953; Ph.D., Stanford, 1957.

Nancy Larrick (1964, 1967)
Adjunct Professor of Education
B.A., Goucher, 1930; M.A., Columbia, 1937; Ed.D., N.Y.U., 1955.

Bruce Alan Laub (1965, 1968)
Administrative Assistant, Fritz Engineering Laboratory
B.S., Lehigh, 1961; M.B.A., 1968.

Leslie Leber (1969)
Computer Analyst
B.S., Dayton (Ohio), 1967.

William Bader Leckonby (1946, 1962)
Professor of Physical Education and Director of the Division of Athletics and Physical Education
B.S., St. Lawrence, 1939.

Lawrence H. Leder (1968)
Professor and Chairman of History and Coordinator, Lawrence Henry Gipson Institute for Eighteenth-Century Studies
B.A., Long Island, 1949; M.A., N.Y.U., 1950; Ph.D., 1960.

Gerald Grant Leeman (1950, 1970)
Assistant Professor of Physical Education and Assistant to the Director of Athletics
B.A., State College of Iowa, 1948.

Daniel Leenov (1963)
Associate Professor of Electrical Engineering
B.S., George Washington, 1943; M.S., Chicago, 1948; Ph.D., 1951.

Henry Leidheiser, Jr. (1968)
Professor of Chemistry and Director of Center for Surface and Coatings Research
B.S., Virginia, 1941; M.S., 1943; Ph.D., 1946.

Robert Lewis Leight (1963, 1969)
Associate Professor of Education and Director, Division of Secondary Education, School of Education
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., University of 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.

Joseph Francis Libsch (1946, 1969)
Alcoa Foundation Professor of Metallurgy and Materials Science and Vice President—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, Undergraduate Officer
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 of Philosophy and Head, Division of Philosophy
B.S., Northwestern, 1959; M.A., Marquette, 1961; Ph.D., 1963.

Benjamin Litt (1970)
Associate Professor of Management and Marketing
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.

Joanne K. LoGiudice (1971)
Visiting Instructor in Social Relations
B.S., Penn State, 1959; M.S., Lehigh, 1962.

Barbara Long (1971)
Systems Programmer, Administrative Systems Office

Francis A. Long (1971)
Lecturer in Electrical Engineering
B.S., Northeastern.

Roland William Lovejoy (1962)
Associate Professor of Chemistry
B.A., Reed College, 1955; Ph.D., Washington State, 1960.

Le-Wu Lu (1957, 1969)
Professor of Civil Engineering, Graduate Officer
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.

Feng-Shyang Luh (1965, 1968)
Associate Professor of Accounting
B.A., National Taiwan, 1957; M.S., Illinois, 1961; Ph.D., Ohio State, 1965.

J. Gary Lutz (1971)
Assistant Professor of Education
B.S., Lehigh, 1965; M.A., 1968; Ed.D., 1969.

William L. Luyben (1967)
Associate Professor of Chemical Engineering
B.S., Penn State, 1955; M.B.A., Rutgers, 1958; M.S., 1962; Ph.D., Delaware, 1963.

Patricia M. Lyons (1972)
Instructor in Religion Studies
B.S., Ohio, 1968; M.A., Princeton, 1971.

George Buchanan MacDonald (1964, 1972)
Assistant Professor of English
A.B., Boston College, 1962; M.A., Lehigh, 1964.

James Decker Mack (1946, 1950)
Director of Libraries
B.A., Lehigh, 1938; M.A., 1949.

Alistair Kenneth MacPherson (1971)
Associate Professor of Mechanical Engineering and Mechanics
B.S., University of Sydney (Australia), 1957; M.S., 1965; Ph.D., 1967.

Rosemarie A. Maier (1972)
Assistant Professor of English
B.A., Nazareth, 1966; A.M., Illinois, 1967; Ph.D., 1972.

Walter Malich (1971)
Instructor in Military Science
SGM, U.S. Army.

Mary Isabelle Malone (1966)
Secretary to the President
B.A., Rosary College, 1945.

Richard Griffith Malsberger (1959, 1972)
Professor and Chairman of Biology
B.A., Lehigh, 1948; M.S., 1949; Ph.D., 1958.

Donald A. Mankin (1968)
Assistant Professor of Psychology
B.S.E.E., Drexel, 1964; M.A., Johns Hopkins, 1966; Ph.D., 1968.

Arthur Howard Mann (1965, 1970)
Associate Dean of Students
B.A., Wesleyan, 1940; S.T.B., General Theological Seminary, 1944.

John Alexander Manson (1966, 1971)
Professor of Chemistry, and Director of the Polymer Laboratory, Materials Research Center
B.Sc., McMaster University (Ontario), 1949; M.Sc., 1950; Ph.D., 1956.

David L. March (1969, 1971)
Systems Analyst, Administrative Systems Office, and Professor of Education
B.S., Lehigh, 1964; M.Ed., 1965; Ph.D., 1970.

Philip W. Marden (1973)
Visiting Instructor in Social Relations
B.A., Rutgers, 1955; M.A., Illinois, 1960; Ph.D., 1963.

Jesse F. Marsh (1970)
Instructor in Aerospace Studies
Sergeant, USAF.

James Patrick Mathews (1947)
Physiotherapist, Health Service

Joseph Abele Maurer (1947, 1964)
Professor and Chairman of Classics
B.A., Moravian, 1932; M.A., Lehigh, 1936; Ph.D., Penn, 1948.

Gregory T. McAllister, Jr. (1965, 1972)
Professor of Mathematics
B.S., St. Peter's College, 1956; Ph.D., Berkeley, 1962.

Austin V. McClain (1971)
Consultant, Office of the Vice President—Development
B.S., 1930; M.A., 1933; L.H.D., Washington & Jefferson.

George E. McCluskey (1965)
Associate Professor of Astronomy
A.B., Penn, 1960; M.S., 1965; Ph.D., 1965.

Gary E. McConnell (1972)
Group Leader, Applications Programming, Computing Center
B.S., Lehigh, 1968.

Charles Allan McCoy (1968)
Professor and Chairman of the Department of Government
B.S. Ed., Illinois, 1948; M.A., Colgate, 1950; Ph.D., Boston University, 1958.

Joseph Brendan McFadden (1948, 1961)
Professor and Head, Division of Journalism
B.A., St. Joseph's (Canada), 1941; M.A., Syracuse, 1948.

William J. McGarry (1969, 1973)
Director, Administrative Systems Office
B.S., King's College, 1965; M.B.A., University of Scranton, 1967.

James Willard McGeady (1950, 1959)
Associate Director of Admission
B.A., Lehigh, 1950.

Edward H. McGee (1970)
Adjunct Professor of Law
A.B., Lehigh, 1952; LL.B., Yale, 1955.

Anthony J. McHugh (1971, 1972)
Assistant Professor of Chemical Engineering
B.S., Cleveland, 1966; M.S., Delaware, 1970; Ph.D., 1972.

Donald McIlvain (1970)
Lecturer in Industrial Engineering
B.S., Penn, 1952; M.S., 1959.

James Rathburn McIntosh (1966, 1970)
Assistant Professor of Sociology
B.A., Colby, 1960; M.A., Syracuse, 1963; Ph.D., 1969.

James Alan McLennan, Jr. (1948, 1968)
Professor and Chairman of Physics
A.B., Harvard, 1948; M.S., Lehigh, 1950; Ph.D., 1952.

Grayson E. McNair (1970)
Lecturer in Electrical Engineering
B.S.E.E., Virginia, 1962.

Judith E. McNally (1972)
Serials Assistant, Linderman Library

John R. McNamara (1973)
Assistant Professor of Economics
B.A., Columbia College, 1959; M.S., Rensselaer, 1965; Ph.D., 1971.

Charles R. McNaron (1969)
Head Football Trainer and Instructor in Physical Education
B.S., Mississippi State, 1965.

Albert E. Meder, Jr. (1968)
Adjunct Professor of Education
A.B., Columbia, 1922; M.A., 1923; LL.D., Fairleigh Dickinson, 1956; L.H.D. (Hon.), Bloomsburg, 1961.

Norman Paul Melchert (1962, 1967)
Associate Professor of Philosophy
B.A., Wartburg, 1955; B.D., Lutheran Theological Seminary, 1958; M.A., Penn, 1959; Ph.D., 1964.

Joseph Robert Merkel (1962, 1965)
Professor of Biochemistry and Director, Marine Biochemistry Laboratory, CMES
B.S., Moravian, 1948; M.S., Purdue, 1950; Ph.D., Maryland, 1952.

Fortunato Joseph Micale (1962, 1970)
Associate Professor of Chemistry
B.A., St. Bonaventure, 1956; B.S., Niagara, 1959; M.S., Purdue, 1961; Ph.D., Lehigh, 1965.

John Anthony Mierzwa (1966, 1972)
Professor of Education and Director, Division of Counselor Education, School of Education
B.S., Ohio, 1954; M.A., 1955; Ed.M., Harvard, 1958; Ed.D., 1961.

Gombilenga Mikongomi (1970)
Visiting Instructor in Kiswahili, Modern Foreign Languages and Literatures
Certificate, Kivukoni College (Tanzania), 1962; Certificate, Mlonot Company Ltd. (Tel Aviv), 1965.

Larry M. Miley (1967)
Assistant Accountant
B.S., Penn State, 1964.

Paul Theodore Miller (1961, 1972)
Superintendent of Buildings and Grounds

Paul Van Reed Miller (1966, 1968)
Associate Professor of Education and Director, Division of Educational Measurements and Research, School of Education
B.A., Yale, 1946; M.A., Penn, 1948; Ph.D., 1965.

Richard W. Miller (1968)
Intern Supervisor of Education
B.S., Kutztown State, 1958; M.A., Lehigh, 1962.

Robert Hugh Mills (1964, 1967)
Professor and Chairman of Accounting
B.S., Colorado, 1949; M.S., 1955; Ph.D., Wisconsin, 1960. C.P.A., Illinois, 1957.

Samuel Harold Missimer (1950, 1962)
Director of Admission
B.A., Lehigh, 1950.

Sitsansu S. Mittra (1968, 1970)
Adjunct Assistant Professor of Mathematics
M.A., Calcutta; M.S., University of Toronto; Ph.D., Lehigh, 1971.

Albert Charles Molter (1960)
Purchasing Agent
B.S., Norwich, 1928; M.S., Lehigh, 1969.

Sutton Monro (1959, 1964)
Professor of Industrial Engineering
B.S., M.I.T., 1942.

Carl Leland Moore (1948, 1963)
Professor of Accounting
A.B., Bucknell, 1943; M.A., Pittsburgh, 1948. C.P.A., Pennsylvania, 1952.

Charles M. Morris (1967)
Adjunct Professor of Psychology
A.B., Bucknell, 1931; M.Ed., 1932; Ph.D., N.Y.U., 1938.

John H. Morrison (1968)
Operations Supervisor, Computing Center

Willard Austin Murray (1972)
Assistant Professor of Civil Engineering
B.S., Wisconsin, 1965; M.S., 1966; Ph.D., 1970.

Paul Benton Myers, Jr. (1962, 1965)
Associate Professor of Geology
A.B., Colgate, 1955; M.S., Lehigh, 1597; Ph.D., 1960.

Benjamin Edward Nevis (1960, 1968)
Adjunct Professor of Mechanical Engineering
B.S., Lehigh, 1955; M.S., 1960; Ph.D., 1965.

William Newman (1968)
Assistant Professor of Psychology
B.S., CUNY (Brooklyn), 1964; Ph.D., Stanford, 1968.

James Walter Niemeyer (1968, 1970)
Executive Director, Alumni Association
B.S., Lehigh, 1943.

Caroline Gladys Nippert (1971)
Science Cataloger
B.A., Dowling, 1968; M.L.S., Pittsburgh, 1971.

Michael Richard Notis (1967, 1969)
Assistant Professor of Metallurgy and Materials Science
B.S., Lehigh, 1960; M.S., 1963; Ph.D., 1969.

Robert Warren Numbers (1960, 1972)
Director of Physical Plant
B.S., Lehigh, 1950.

John J. O'Connor (1967)
Research Associate Professor of Philosophy, Center for Information Science
B.A., Columbia, 1945; M.A., Cornell, 1947; Ph.D., Columbia, 1952.

William Edward Ohnesorge (1965, 1971)
Professor of Chemistry
Sc.B., Brown, 1953; Ph.D., M.I.T., 1956.

John Ondria (1967, 1970)
Associate Professor of Electrical Engineering
B.S., Lehigh, 1960; M.S., 1963; Ph.D., 1967.

Kenneth Everett Orben (1963)
Assistant Superintendent of Buildings and Grounds
B.S., Penn State, 1947.

Joseph C. Osborn (1946, 1961)
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
Dipl. Ing., Munich Institute of Technology, 1951; Sc.D., M.I.T., 1957.

Peggy A. Ota (1971)
Assistant Professor of Electrical Engineering
B.A., Cornell, 1966; M.S., Penn, 1969.

Eric Van Tine Ottervik (1966, 1969)
Vice Provost and Coordinator of University 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.

Bradford Breckenridge Owen (1945, 1948)
Associate Professor of Biology
B.A., Williams, 1934; M.A., 1936; Ph.D., Harvard, 1940.

John B. Owens (1973)
Assistant Professor of History
B.A., Oberlin, 1966; M.A., Wisconsin, 1960; Ph.D., 1972.

Mustafa R. Ozgu (1972)
Assistant Professor of Mechanical Engineering
B.S., Middle East Technical University (Ankara, Turkey), 1967; M.S., 1968; Ph.D., Lehigh, 1971.

Anthony Packer (1946, 1950)
Assistant Professor of Physical Education and Assistant to the Director in Charge of Fields
B.S., St. Lawrence, 1938.

Sara Louise Paden (1971)
Administrative Assistant, University Publications
B.A., Moravian, 1971.

Artis J. Palmo (1971)
Assistant Professor of Education
B.S., California State (Pennsylvania), 1967; M.A., West Virginia, 1968; Ed.D., 1971.

Robert Roupen Panos (1964, 1969)
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.

Basil Waldo Parker (1940, 1954)
Professor of Biology
S.B., M.I.T., 1933; A.M., Harvard, 1935; Ph.D., M.I.T., 1939.

Lloyd C. Parker (1971)
Instructor in Education
B.A., Connecticut College, 1956.

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)
Instructor in Education
B.S., Simmons, 1945; M.A., Lehigh, 1969.

Elizabeth Patterson (1970)
Administrative Secretary, Forum Office

John B. Pearce (1966)
Adjunct Professor of Biology
A.B., Humboldt State, 1957; M.S., Washington, 1960; Ph.D., 1962.

John M. Pearson (1972)
Associate Professor of English and Head, Division of Speech
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.

Robert A. Pfennig (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.

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.

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.

William Leroy Quay (1963, 1970)
Dean of Student Life
A.B., Muhlenberg, 1956; A.M., Penn, 1957; Ph.D., Lehigh, 1969.

Clifford Steven Queen (1972)
Assistant Professor of Mathematics
Ph.D., Ohio State, 1969.

Shelden Henry Radin (1963, 1968)
Associate Professor of Physics
B.S., Worcester Polytechnic, 1958; M.S., Yale, 1969; Ph.D., 1963.

Beegamudre Rakosh-Das (1967)
Instructor in Electrical Engineering
B.Sc., Engineering, Banaras, 1949; A.I.I.Sc., Bangalore, 1952.

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 and Personnel 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., Penn, 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 Director of Admission
B.A., Drew, 1966.

Robert E. Reidnauer (1961, 1972)
Operations Supervisor of Administrative Systems

Frederick Eugene Ressler (1952, 1964)
Associate Registrar
B.A., Lehigh, 1952.

Rodney Earl Ressler (1947, 1964)
Assistant Registrar

Joseph H. Reynolds (1970)
Assistant to the Dean of Student Life
B.A., Lehigh, 1968; M.A., 1972.

Adrian F. Richards (1969)
Professor of Oceanography and Ocean Engineering and Director, Marine Geotechnical Laboratory, CMES
B.S., New Mexico, 1951; Ph.D., University of California, Scripps Institution of Oceanography, 1957.

Berry Gargal Richards (1969)
Associate Librarian, Mart Science and Engineering Library and Secretary to the Faculty
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.

Martin L. Richter (1965, 1972)
Associate Professor of Psychology
B.A., Rutgers, 1960; Ph.D., Indiana, 1965.

James Peter Ries (1967)
Assistant Professor of Mechanical Engineering
B.S.M.E., Iowa, 1964; Ph.D., 1967.

Mary Gruber Riley (1953, 1968)
Head Reference Librarian, Linderman Library
B.A., Penn State, 1952; M.S. in L.S., Drexel, 1953.

Alice Duffy Rinehart (1964, 1969)
Assistant Professor of Education and Coordinator of Educational Placement
B.A., Smith, 1947; M.Ed., Lehigh, 1965; Ed.D., 1969.

Deborah J. Ritter (1972)
Administrative Assistant, Fritz Engineering Lab
B.A. in Fine Arts, Toepaste Kunsten (Maastericht, Holland), 1969.

Donald L. Ritter (1969)
Assistant to the Vice President—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.

Margaret Ellen Felice Rocheleau (1971)
Assistant to the Editor, Alumni Bulletin
B.A., Muhlenberg, 1968.

Donald O. Rockwell, Jr. (1970, 1972)
Associate Professor of Mechanical Engineering and Mechanics
B.S., Bucknell, 1964; M.S., Lehigh, 1965; Ph.D., 1968.

Alberto Romero (1967)
Instructor in Spanish, Modern Foreign Languages and Literatures
B.A., S. Esteban (Salamanca), 1960; Lic., Angelicum (Rome), 1961; M.A., Penn, 1971.

Robert E. Rosenwein (1972)
Assistant Professor of Social Relations
B.A., Berkeley, 1962; M.A., 1963; Ph.D., Michigan, 1970.

H. Joris Rosse (1972)
Director of Physical Planning
B.A., Idaho, 1954.

Herbert Rubenstein (1967, 1973)
Professor of Philosophy and Adjunct Professor of Psychology
B.A., Penn, 1942; M.A., 1943; Ph.D., Columbia, 1949.

Leonard I. Ruchelman (1969, 1972)
Associate Professor of Government and Head, Division of Urban Studies
B.A., Brooklyn College, 1954; Ph.D., Columbia, 1965.

Sylvia Rutkoff (1966)
Lecturer in Education
B.A., Hunter, 1940; M.A., Columbia Teacher's College, 1958.

J. Donald Ryan (1952, 1962)
Professor of Geology and Chairman of Geological Sciences
B.A., Lehigh, 1943; M.S., 1948; Ph.D., Johns Hopkins, 1952.

James S. Saeger (1967, 1969)
Assistant Professor of History
B.A., Ohio State, 1960; M.A., 1963; Ph.D., 1969.

Eric Paul Salathe (1967, 1970)
Associate Professor, Center for the Application of Mathematics
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.

Brian Sanders (1969)
Associate Librarian, Linderman Library
B.A., Nottingham, 1959; M.A., London, 1964; M.L.S., Rutgers, 1967.

Robert Guy Sarubbi (1968)
Associate Professor of Mechanics
B.Sc.E., Cooper Union, 1953; M.S., Lehigh, 1957; Ph.D., 1963.

Kenneth N. Sawyers (1969)
Assistant Professor, Center for the Application of Mathematics
B.S., I.T.T., 1962; Ph.D., Brown, 1967.

Stephen Alan Schafer (1967)
Visiting Lecturer in Education
B.A., Delaware, 1949; M.H.L., Hebrew Union College, 1955; Ed.D., Lehigh, 1971.

Murray Schechter (1963, 1968)
Associate Professor of Mathematics
A.B., Brooklyn, 1957; M.A., N.Y.U., 1959; Ph.D., 1964.

William Edward Schiesser (1960, 1963)
Professor of Chemical Engineering and Analyst, Computing Center
B.S., Lehigh, 1955; M.A., Princeton, 1958; Ph.D., 1960.

Stephen Allen Schmidt (1971)
Assistant Professor of Military Science
B.S., LaSalle, 1963. Captain, Infantry, U.S. Army.

Edward Wilfred Schmitt (1968)
Instructor in Marketing and Management
B.S., Drexel, 1960; M.B.A., 1964.

Donald Walter Schmoyer (1946, 1962)
Assistant Treasurer
B.S., Lehigh, 1944.

John A. Schnaible (1969)
Instructor in Speech
B.A., Indiana, 1967; M.A., Colorado State, 1969.

Donald D. Schneider (1972)
Assistant Professor of Fine Arts and Director of Exhibitions and Curator
A.B., Wesleyan, 1957; M.F.A., Princeton, 1960; Ph.D., 1971.

Keith J. Schray (1972)
Assistant Professor of Chemistry
B.S., University of Portland, 1965; Ph.D., Penn State, 1970.

Henry J. Schreitmueller (1972)
Instructor in Education
A.B., Seton Hall, 1952; M.A., 1970; M.A., Catholic University, 1971.

Stanley Robert Schultz (1966)
Instructor in Physical Education, Varsity Baseball Coach
B.A., Trenton State, 1964.

Eli Schwartz (1954, 1962)
Professor of Economics and Finance
B.S., Denver, 1943; M.A., Connecticut, 1948; Ph.D., Brown, 1952.

Charles Bertrand Sclar (1968)
Professor of Geology
B.S., CUNY, 1946; M.S., Yale, 1948; Ph.D., 1951.

Joseph F. Scullion, Jr. (1972)
Manager, Special Projects and Program Development, and Director of Computing Associates Program, Computing Center
B.S., Drexel, 1966.

Andrea Jane Sedlak (1971)
Visiting Instructor in Social Relations
A.B., Rutgers, 1968.

Margaret Melchior Seylar (1966)
Adjunct Professor in Education
B.S., Kutztown State, 1945; M.A., Lehigh, 1956.

Sandra Shaber (1972)
Visiting Instructor in Government
B.S., Ohio State, 1957; M.A., 1959.

William Gerald Shade (1966, 1969)
Associate Professor of History
A.B., Brown, 1961; M.A., 1962; Ph.D., Wayne State, 1966.

Diane Kay Shaffer (1971)
Assistant to the Director, Public Information
B.S., Syracuse, 1970.

Russell Allen Shaffer (1964, 1967)
Associate Professor of Physics
B.S., Drexel, 1956; Ph.D., Johns Hopkins, 1962.

Ching Sheng Shen (1964, 1968)
Associate Professor of Economics
B.A., Yen-Ching University, 1941; M.A., Boston University, 1951; Ph.D., North Carolina, 1957.

William F. Shimonkevitz (1972)
Professor of Aerospace Studies
B.S., Nebraska, 1952; M.S., George Washington, 1966.
Colonel, U.S.A.F.

M. Wayne Shiveley (1968, 1971)
Assistant Professor of Industrial Engineering
B.S., Missouri, 1960; B.S., 1965; M.S., 1967; Ph.D., Lehigh, 1971.

George K. Shortess (1969)
Associate Professor of Psychology and Director, Division of Visual Science, Center for Health Sciences
A.B., Lycoming, 1954; M.A., Brown, 1960; Ph.D., 1962.

Thomas D. Shreiner (1970)
Assistant Football and Lacrosse Coach and Instructor in Physical Education
B.S., Gettysburg, 1963.

Robert Peter Shurtleff (1963, 1972)
Director of Residence Halls and Assistant Dean of Residence
B.A., Lehigh, 1955; M.Ed., 1964.

William Joseph Sibley (1964)
Counselor, Counseling Service
B.S., East Stroudsburg State, 1955; M.Ed., Lehigh, 1964.

Sharon Lois Siegler (1971)
Reference Librarian, Mart Library
B.A., University of Maine, 1969; M.L.S., New York at Albany, 1971.

George C. M. Sih (1958, 1965)
Professor of Mechanics and Director, Institute of Fracture and Solid Mechanics
B.S., Portland, 1953; M.S., New York, 1957; Ph.D., Lehigh, 1960.

David K. Silhanek (1972)
Visiting Assistant Professor of Classics
A.B., Princeton, 1957; M.A. (Latin), Michigan, 1968; M.A. (Greek), 1969; Ph.D., N.Y.U., 1972.

Ruth Silverman (1971)
Assistant Professor of Mathematics
A.B., Syracuse, 1956; M.S., Cornell, 1958; Ph.D., University of Washington, 1970.

Gary W. Simmons (1970)
Assistant Professor of Chemistry
B.S., West Virginia, 1961; Ph.D., 1967.

Marvin Howard Simmons (1970, 1973)
Assistant Director of University Publications
B.A., Juniata, 1964; B.F.A. and M.F.A., Yale, 1970.

Roger D. Simon (1970, 1971)
Assistant Professor of History
A.B., Rutgers, 1965; M.A., Wisconsin, 1966, Ph.D., 1971.

Dale Rodekohr Simpson (1960, 1966)
Professor of Geology
B.S., Penn State, 1956; M.S., Cal Tech, 1958; Ph.D., 1960.

Kenneth P. Sinclair (1972)
Assistant Professor of Accounting
B.A., Massachusetts, 1968; M.S., 1970; Ph.D., 1972.

Herbert Bancroft Skerry (1967)
Assistant Professor of Mathematics
A.B., Harvard, 1954; M.S., Wisconsin, 1958; Ph.D., Michigan, 1967.

Zdenek J. Slouka (1972)
Visiting Associate Professor of International Relations
B.A., Masaryk University (Czechoslovakia), 1948; M.A., N.Y.U. 1958; Ph.D., Columbia, 1965.

Roger George Slutter (1961, 1969)
Associate Professor of Civil Engineering and Director of Operations, Fritz Engineering Laboratory
B.S., Lehigh, 1953; M.S., 1956; Ph.D., 1968.

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.

Gerald Francis Smith (1965)
Professor, Center for the Application of Mathematics
B.S., Buffalo, 1953; Ph.D., Brown, 1956.

John Edwin Smith (1967, 1972)
Manager, Computer Services, Computing Center
B.A., Wesleyan, 1950; M.A., 1952; B.S., Canisius, 1958.

Margaret N. Smith (1968)
Assistant Librarian, Acquisitions
A.B., Oberlin, 1940; M.L.S., Drexel, 1966.

Wesley Richard Smith (1958, 1968)
Professor of Physics
B.S., Lehigh, 1950; M.S., 1951; Ph.D., Princeton, 1957.

William Adams Smith, Jr. (1955, 1968)
Professor of Industrial Engineering
B.S., U.S. Naval Academy, 1951; M.S., Lehigh, 1957; Ph.D., N.Y.U., 1966. P.E., Pennsylvania, 1959.

Oles M. Smolansky (1963, 1970)
Professor of International Relations
A.B., N.Y.U., 1953; A.M., Columbia, 1955; Ph.D., 1959.

Mervin Philip Smolinsky (1970)
Adjunct Associate Professor of Psychology
B.A., Temple, 1951; M.S., Pittsburgh, 1966; Ph.D., 1969.

Donald Morgan Smyth (1971)
Director, Materials Research Center and Associate Professor, Metallurgy and Materials Science and Chemistry
B.S., Maine, 1951; Ph.D., M.I.T., 1954.

Max Donald Snider (1946, 1967)
Associate Professor of Marketing and Assistant 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.

William J. Snyder (1967)
Postdoctoral Fellow in Chemical Engineering
B.S., Penn State, 1963; M.S., 1965; Ph.D., 1967.

Anne C. Solderitsch (1972)
Assistant to the Planner, Campus Planning Office

Albert J. Solomon (1969)
Assistant Professor of English
B.A., University of Scranton, 1962; M.A., 1964; Ph.D., Penn State, 1969.

Barbara E. Solt (1970)
Coordinator of Volunteer Community Services
A.B., Muhlenberg, 1965; M.S.S.W., Columbia, 1967.

Erwin Alfred Sommer (1967)
Research Associate in Mechanics
Dipl. Phys., University of Gottingen (Germany), 1962; Dr. Rer. Nat., University of Freiburg (Germany), 1966.

Wilbur Devilla Bernhart Spatz (1946, 1970)
Professor of Physics
B.S., Lafayette, 1930; M.S., Purdue, 1934; Ph.D., New York, 1943.

Leslie H. Sperling (1967)
Assistant 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—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.

Sidney Stecher (1972)
Associate Professor of Psychology
B.B.A., CCNY, 1957; M.S., 1959; Ph.D., CUNY, 1966.

John Stohler Steckbeck (1962)
Assistant Professor of Physical Education and Assistant Director, Physical Education and Intramurals
B.S., West Chester State, 1936; M.Sc., Penn, 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.

Alan Hugh Stenning (1965)
Professor of Mechanical Engineering
B.Sc., Glasgow University, 1950; M.S., M.I.T., 1951; Sc.D., 1955.

Theodore M. Stephens, Jr. (1971)
Instructor in Education
B.S., Patterson State, 1957; M.S., 1959.

Louis W. Stern (1970)
Assistant Professor of Philosophy
B.A., Temple, 1964; M.A., Lehigh, 1966; Ph.D., 1970.

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., Penn, 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.

Carl Ferdinand Strauch (1934, 1953)
Distinguished Professor of English
A.B., Muhlenberg, 1930; M.A., Lehigh, 1934; Ph.D., Yale, 1946.

Karol Strelecki (1971)
Instructor in Education
B.S., Rutgers, 1961; M.S., Temple, 1970.

Joseph Strickland, Jr. (1972)
Instructor in Education
B.A., Lehigh, 1972.

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)
Associate 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.B.E., B.S., Brooklyn Polytechnic, 1948; S.M., M.I.T., 1950.

Harry O. Tachovsky (1971)
Instructor in Education
B.S., Kutztown State, 1970.

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, 1967)
Associate Professor of Metallurgy and Materials Science
B.S., Carnegie-Mellon, 1956; M.S., 1958; Ph.D., 1962.

Ann Tarola (1972)
Instructor in Education
B.S., Penn State, 1965; M.Ed., Lehigh, 1972.

Catherine Tarrant (1972)
Assistant Professor of History
B.A., Illinois, 1968; Ph.D., Rice, 1972.

Merle W. Tate (1965)
Professor of Education, Graduate Student Advisor
A.B., Central Wesleyan, 1926; M.A., Montana, 1943; Ed.M., Harvard, 1946; Ed.D., 1947.

Robert Sayre Taylor, Jr.
Legal Counsel
B.A., Lehigh, 1925; LL.B., Penn, 1928.

Everett Anderson Teal (1945)
Director of Placement and Personnel Services
B.S., Ball State Teachers, 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.

John H. C. Thompson (1968)
Visiting Professor, Center for the Application of Mathematics
B.A., New College (Oxford), 1930; M.A., D.Ph.L., 1933.

H. Louis Thompson (1969, 1972)
Adjunct Professor of Accounting
B.S., Lehigh, 1930; M.B.A., 1965.

Robert J. Thornton (1970)
Assistant Professor of Economics
A.B., Xavier, 1965; M.A., Illinois, 1967; Ph.D., 1970.

James A. Tiefenbrunn (1969, 1972)
Assistant Director of Residence Halls and Assistant Dean of Residence
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.

Linda L. Tipton (1972)
Assistant to the Director of Admission
B.A., Dickinson, 1971.

Doris Mae Transue (1964)
Nurse, Health Service
R.N., St. Luke's, 1947.

Louis Reed Tripp (1964)
Frank L. Magee Professor of Business Administration and Acting Coordinator, Center for Social Research
B.A., Union, 1934; Ph.D., Yale, 1942.

Edward J. Trost (1971, 1972)
Assistant Director of Placement and Personnel Services
A.B., Michigan, 1941; M.A., Lehigh, 1971.

Kenneth Mangold Trumbore (1946)
Assistant Manager, Bookstore
B.A., Moravian, 1940.

Wendell Piggott Trumbull (1957, 1958)
Professor of Accounting
B.S., Illinois, 1937; M.A., Michigan, 1941; Ph.D., 1954.
C.P.A., Mississippi, 1949.

David Trutt (1965, 1971)
Associate Professor of Mathematics
B.S., Lafayette, 1959; M.S., Brown, 1962; Ph.D., Purdue, 1964.

B. Thayer Turner (1970)
Varsity Wrestling Coach
B.S., Lehigh, 1961.

LeRoy J. Tuscher (1971)
Assistant Professor of Education
B.S., Northern State, 1958; M.A., Stanford, 1964; Ph.D., Florida State, 1971.

Kenneth Kai-Ming Tzeng (1969)
Assistant 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., Penn, 1934; M.A., 1935; Ph.D., 1960.

Dean Pearson Updike (1965)
Assistant 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)
Associate 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)
Assistant Professor of Spanish, Modern Foreign Languages and Literatures
B.A., Carleton University (Ottawa), 1963; M.A., Illinois, 1965; Ph.D., 1967.

George VanDoren (1971)
Instructor in Education
B.A., Lehigh, 1969; M.A., 1971.

John Andrews Van Eerde (1960, 1963)
Professor of French, Modern Foreign Languages and Literatures
A.B., Harvard, 1938; M.A., 1939; Ph.D., Johns Hopkins, 1953.

Nan Van Gieson (1973)
Assistant Director of Summer Session and Assistant Dean of Education
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)
Assistant 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)
Reference Librarian, 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, 1966)
Associate Professor of English
Ph.B., Chicago, 1949; A.M., 1952; Ph.D., Indiana, 1960.

Charles F. Vihon (1969)
Assistant Professor of Law
B.S., Northwestern, 1959; J.D., Chicago, 1962.

Edwin M. Wagner (1966)
Assistant Professor of Aerospace Studies
B.G.E., Omaha, 1965. Major, USAF.

James Harold Wagner (1949, 1951)
Registrar
B.A., Gettysburg, 1947; M.A., Pennsylvania, 1950.

D. Alexander Waldenrath (1968, 1969)
Assistant 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.

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.

Robert Pey-Ying Wei (1966, 1970)
Professor of Mechanics
B.S., Princeton, 1953; M.S., 1954; Ph.D., 1960.

Daniel Jacob Roger Weine (1972)
Humanities Cataloger
B.A., Vermont, 1961; M.A.T., Harvard, 1962; A.M.L.S., Michigan, 1967.

Andrew R. Weintraub (1966)
Assistant Professor of Economics
B.A., Rutgers, 1961; M.A., 1964; Ph.D., 1966.

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.

John Calvin Whitehead (1967)
Instructor in Physical Education and Assistant Varsity Football Coach
B.S., East Stroudsburg State, 1950.

Gary E. Whitehouse (1965, 1969)
Associate 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, USAF.

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.

Willard Ross Yates (1955, 1963)
Professor of Government
B.A., Oregon, 1948; M.A., 1949; Ph.D., Yale, 1956.

Bung-Tseng Yen (1957, 1968)
Associate Professor of Civil Engineering
B.S., National Taiwan, 1955; M.S., Lehigh, 1959; Ph.D., 1963.

Carl L. Young (1972)
Staff Assistant, Aerospace Studies
Master Sergeant, USAF.

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)
Assistant 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.

Earl R. Zimmerman (1968)
Instructor in Education
B.S., California State, 1944; M.Ed., Penn State, 1954.

Emory W. Zimmers, Jr. (1969)
Instructor in Industrial Engineering
B.S., Lehigh, 1966; B.S., 1967; M.S., 1967.

Charles Keller Zug (1961)
Advisor on Bequests, Trusts, and Insurance
B.S. in I.E., Lehigh, 1927; B.S. in E.E., 1927.

Emeriti

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.

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.

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.

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.

William Joseph Ency (1936, 1971)
Joseph T. Stuart Professor Emeritus of Civil Engineering
B.S., Johns Hopkins, 1927; M.S., Lehigh, 1938. P.E., Pennsylvania, 1939.

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.

George Rankin Irwin (1967, 1972)
Boeing University Professor Emeritus of Mechanics
A.B., Knox College, 1930; M.S., Illinois, 1933; Ph.D., 1937.

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., Penn, 1929; M.D., 1932.

Archie Roscoe Miller (1922, 1961)
Professor Emeritus of Electrical Engineering
B.S., Illinois, 1918; M.S., Lehigh, 1925.

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.

Howard Charles Pieper (1967, 1973)
University Physician Emeritus
B.S., Iowa State, 1926; M.D., 1932.

Francis Joseph Quirk (1950, 1972)
Professor Emeritus of Fine Arts
Dipl., Rhode Island School of Design, 1929.

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.

Ernest Bernhard Schulz (1927, 1965)
Professor Emeritus of Political Science
B.S., Michigan, 1920; M.A., 1921; Ph.D., 1927.

Charles Augustus Seidle (1948, 1962)
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.

Milton Caleb Stuart (1926, 1952)
Professor Emeritus of Mechanical Engineering
B.S., Penn, 1909; M.E., 1924.

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.

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.

Bradford Willard (1939, 1959)
Professor Emeritus of Geology
B.A., Lehigh, 1921; A.M., Harvard, 1922; Ph.D., 1923.

Ralph Charles Wood (1958, 1961)
Professor Emeritus of German
B.A., and B.E., Cincinnati, 1928; M.A., 1930; Ph.D., Cornell, 1933.

Resignations and Retirements

Thomas Althouse (1971)
Visiting Assistant Professor of Fine Arts

Charles Arthur Apple (1970)
Instructor in Metallurgy and Materials Science

Fred Assenheimer (1970, 1971)
Assistant Executive Secretary, Alumni Association

Howard J. Axon (1971)
National Science Foundation Visiting Senior Scientist in Metallurgy and Materials Science

John Ross Baker (1962, 1971)
Lecturer in English

Richard H. Barkalow (1970)
Instructor in Metallurgy and Materials Science

Allen Merril Barstow (1967)
Instructor in Romance Languages

Inge F. Bennett (1971)
Research Associate, Psychology

Raymond W. Bennett (1971)
Assistant Professor of Psychology

Vahram Biricikoglu (1966, 1968)
Assistant Professor of Mechanics

Harold Clarke (1967)
Lecturer and Technician in Physics

Percy Elwood Corbett (1964)
Adjunct Professor of International Relations

Keith H. Corkum (1970)
Instructor in Economics

Joseph A. Corrado (1963, 1967)
Instructor in Civil Engineering

Mildred J. Crosby (1962)
Psychometrician, Counseling

Osman A. El-Ghamry (1969)
Visiting Assistant Professor of Civil Engineering

George Tyler Embley (1970)
Assistant Professor of Mechanical Engineering and Mechanics

David M. Fairhurst (1969)
Research Associate, Center for Surface and Coatings Research

Robert Donald Gaines (1971)
Instructor in Military Science

Leanor Ruth Gilbert (1930, 1943)
Recorder

Richard Allyn Gonce (1965)
Assistant Professor of Economics

James B. Goyne (1969)
Psychiatrist, Health Service

Lloyd Hitchcock, Jr. (1966)
Adjunct Professor of Psychology

John William Humes (1969)
Assistant Professor of Philosophy and Information Science

Sampath N. S. Iyengar (1969)
Instructor in Civil Engineering

Pierre Juliard (1968)
Assistant Professor of History

Miguel Angel Macias, Jr. (1965)
Instructor in Civil Engineering

Ronald Bennett Madison (1964)
Instructor in Civil Engineering

George D. Marsh, Jr. (1965)
Assistant Professor of Psychology

Lynne Carol Marsh (1971)
Social Science Cataloger

Walter Frederick Marshall (1967)
Instructor in Romance Languages

Leslie Guy McCracken, Jr. (1956)
Associate Professor of Electrical Engineering

Donald Frazier McLeroy (1966)
Assistant Professor of Geology

Michael P. Mortell (1967, 1972)
Associate Professor, Center for the Application of Mathematics

John Wayne Murphy (1962, 1964)
Director of University Publications

Linda A. Myers (1970)
Humanities Cataloger

Lajos G. Nagy (1970)
Visiting Research Associate Professor, Center for Surface and Coatings Research

Judith Neale (1969)
Instructor in Centennial School

William L. Nelson (1969)
Instructor in Centennial School

Julius Nimmons (1970)
Lecturer in History

Monroe C. Nichols (1968)
Instructor in Physical Education

Thomas Russell Ortolano (1965)
Assistant Professor of Chemistry

Paul Croce Paris (1955, 1965)
Professor of Mechanics

Donald G. Podoll (1969)
Staff Sergeant, Aerospace Studies

Betty Potash (1970)
Assistant Professor of Cultural Anthropology

Donald L. Prullage (1968)
Assistant Professor of Mathematics

Peter Jules Richetta (1965, 1966)
Assistant Professor of Mathematics

Fred S. Sauerwine (1966, 1971)
Visiting Assistant Professor in Metallurgy and Materials Science

Richard N. Sopko (1961)
Photographer—Draftsman in Civil Engineering

Glenn E. Stauffer (1969)
Professor of Aerospace Studies

Joseph C. Surico (1969)
Assistant Professor of Aerospace Studies

Hugh T. Sutherland (1967)
Instrument Associate in Civil Engineering

Douglas Henley Taylor (1964, 1965)
Assistant Professor of Mathematics

Peter Tinker (1971)
Instructor in English

John Thomas Hanley Timm (1967)
Instructor in Romance Languages

Frank Van der Woude (1970)
Postdoctoral Research Associate in Civil Engineering

Leo F. Van Hoey (1969)
Associate Professor of Sociology

Bruce A. Wagaman (1969)
Assistant Accountant

Walter Barry Wagner (1968)
Instructor in Mechanical Engineering

John Loren Washburn (1965)
Assistant Professor of Government

Richard A. K. Watt (1969)
Assistant Professor of German and Russian

Ben L. Wechsler (1969)
Professor of Military Science

Michael Wilkinson (1971)
Postdoctoral Research Associate in Center for Surface and Coatings Research

Elizabeth E. M. Williams (1969)
Visiting Lecturer in Education

Deceased

Fay Conant Bartlett (1917, 1956)
Assistant Professor Emeritus of Physical Education
December 28, 1971.

Francis Mario Brady, Jr. (1955, 1970)
Associate Professor of Accounting
July 30, 1972.

Merton Otis Fuller (1912, 1955)
Associate Professor Emeritus of Civil Engineering
September 25, 1972.

E. Everett MacNamara (1968)
Assistant Professor of Geology
December 16, 1972.

Registration Statistics

Spring, 1970		Summer, 1970		Fall, 1970	
Undergraduate Students	3042	Undergraduate Students	335	Undergraduate Students	3166
Graduate Students	1788	Graduate Students	1254	Graduate Students	1933
Special Students	24			Special Students	46
Total	4854	Total	1589	Total	5145

Students in Undergraduate Curricula Spring, 1970

Curriculum	Seniors	Juniors	Sophomores	Freshmen	G.C.D.	Total
Arts and Science	249	237	234	244		964
Arts and Engineering	22	16	27	27		92
Business and Economics	160	145	139	105		549
Chemical Engineering	40	50	51			141
Chemistry	13	16	23			52
Civil Engineering	32	37	44			110
Electrical Engineering	64	74	66			204
Engineering Mechanics	3	2	6			11
Engineering Physics	13	3	15			31
Fundamental Science	5	8	17			30
Industrial Engineering	37	47	47			131
Mechanical Engineering	67	62	52			181
Metallurgy and Materials Science	36	23	20			79
Unclassified Engineers		1	10	451		462
General College Division					5	5
Total	741	721	748	827	5	3042

Students in Undergraduate Curricula Fall, 1970

Curriculum	Seniors	Juniors	Sophomores	Freshmen	G.C.D.	Total
Arts and Science	230	232	241	234		937
Arts and Engineering	18	22	17	43		100
Business and Economics	144	131	127	128		530
Chemical Engineering	52	48	67			167
Chemistry	13	22	14			49
Civil Engineering	34	41	64			139
Electrical Engineering	70	66	84			220
Engineering Mechanics	2	7	1			10
Engineering Physics		14	13			27
Fundamental Science	7	20	18			45
Industrial Engineering	44	43	44	2		133
Mechanical Engineering	68	56	55			179
Metallurgy and Materials Science	25	18	33			76
Unclassified Engineers		6	30	510		546
General College Division					8	8
Total	707	726	808	917	8	3166

Geographical Distribution of Undergraduate Students Fall, 1970

Alabama	1	New Hampshire	6	Bermuda	1
California	10	New Jersey	663	Canada	3
Colorado	4	New Mexico	3	Chile	1
Connecticut	105	New York	450	Colombia	1
Delaware	26	North Carolina	5	Ecuador	1
District of Columbia	13	Ohio	41	Germany	1
Florida	14	Pennsylvania	1513	Ghana	1
Georgia	3	Rhode Island	8	Greece	1
Illinois	21	South Carolina	1	Hong Kong	4
Indiana	6	Tennessee	5	India	1
Iowa	2	Texas	5	Liberia	1
Kentucky	1	Vermont	4	Malaysia	1
Louisiana	7	Virginia	31	Pakistan	1
Maine	3	West Virginia	6	Panama	4
Maryland	96	Wisconsin	5	Peru	1
Massachusetts	59			Phillipines	2
Michigan	7	Africa	1	Puerto Rico	1
Missouri	4	Argentina	4	Switzerland	1
Nebraska	2	Arabia	1	Taiwan	1
Nevada	1	Belgium	2	United Kingdom	3
				Total	3170

Spring, 1971		Summer, 1971		Fall, 1971	
Undergraduate Students	3049	Undergraduate Students	313	Undergraduate Students	3438
Graduate Students	1940	Graduate Students	1382	Graduate Students	1935
Special Students	32	Special Students	8	Special Students	37
Total	5021	Total	1703	Total	5410

Students in Undergraduate Curricula Spring, 1971

Curriculum	Seniors	Juniors	Sophomores	Freshmen	G.C.D.	Total
Arts and Science	279	208	224	226		937
Arts and Engineering	28	14	6	21		69
Business and Economics	150	134	139	152		575
Chemical Engineering	52	45	51			148
Chemistry	12	23	12			47
Civil Engineering	39	36	47			122
Electrical Engineering	74	60	63			197
Engineering Mechanics	2	7				9
Engineering Physics	4	12	7			23
Fundamental Science	13	14	14			41
Industrial Engineering	48	41	32			121
Mechanical Engineering	70	48	51			169
Metallurgy and Materials Science	22	22	32			76
Unclassified Engineers		9	28	469		506
General College Division					9	9
Total	793	673	706	868	9	3049

Students in Undergraduate Curricula Fall, 1971

Curriculum	Seniors	Juniors	Sophomores	Freshmen	G.C.D.	Total
Arts and Science	215	256	286	389		1146
Arts and Engineering	23	11	15	41		90
Business and Economics	126	146	168	149		589
Chemical Engineering	43	52	62	1		158
Chemistry	26	14	25			65
Civil Engineering	46	47	61			154
Electrical Engineering	66	61	86			213
Engineering Mechanics	6	3	3			12
Engineering Physics	12	6	15			33
Fundamental Science	16	19	15			50
Industrial Engineering	43	36	42			121
Mechanical Engineering	51	51	61			163
Metallurgy and Materials Science	16	38	29			83
Unclassified Engineers	2	10	48	475		535
General College Division					26	26
Total	691	750	916	1055	26	3438

Geographical Distribution of Undergraduate Students Fall, 1971

Alabama	2	New Mexico	2	Greece	1
Arizona	1	New York	480	Holland	1
California	9	North Carolina	4	Hong Kong	3
Colorado	3	Ohio	42	India	1
Connecticut	105	Oklahoma	1	Iran	4
Delaware	30	Pennsylvania	1647	Italy	1
District of Columbia	9	Rhode Island	10	Korea	1
Florida	15	South Carolina	1	Liberia	1
Georgia	5	Tennessee	2	Malaysia	1
Illinois	20	Texas	7	Mexico	2
Indiana	4	Vermont	4	Norway	1
Kentucky	3	Virginia	25	Panama	2
Louisiana	7	West Virginia	3	Peru	2
Maine	4			Philippines	1
Maryland	107	Argentina	2	Puerto Rico	1
Massachusetts	55	Belgium	1	Switzerland	1
Michigan	7	Bermuda	1	Taiwan	1
Mississippi	1	Canada	5	United Arab Republic	2
Missouri	3	Colombia	2	United Kingdom	2
Nebraska	2	Dominican Republic	1	Venezula	2
New Hampshire	8	France	2	West Germany	1
New Jersey	788	Ghana	1	Total	3468

Index

Lehigh University Catalog

Second class postage paid at
Bethlehem, Pennsylvania 18015