Lehigh

University Catalog of Curricula,
Courses and Degree Requirements

1971-1973

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Academic Calendar

1971-1972

September 1–9
Graduate registration for fall semester
September 7 (Tues.)
Freshmen Orientation begins
Make-up examinations and special examinations
September 8–9 (Wed., Thurs.)
Last day for October Ph.D. candidates to deliver to Dean of Graduate School approved dissertation draft
September 10 (Fri.)
Last day for filing applications for degrees to be conferred on Founder's Day
Undergraduate registration for fall semester
September 13 (Mon.)
Fall semester instruction begins
First Faculty meeting
September 14 (Tues.)
Last day for October candidates for Master's degrees to deposit with Dean of Graduate School unbound copies of Thesis
September 17 (Fri.)
Last day for October Ph.D. candidates to complete all degree requirements
September 23 (Thurs.)
Last day on which registration for fall courses will be permitted

October 9 (Sat.)
ETS Language examinations for Graduate students
October 10 (Sun.)
Founder's Day
October 11–13 (Mon.–Wed.)
Engineering Inspection Trips

November 8 (Mon.)
Mid-semester reports due
Pre-registration begins
November 13 (Sat.)
Pre-registration ends
November 22–24 (Mon.–Wed.)
Thursday, Friday and Saturday classes
November 24, 1 p.m. (Wed.)
Thanksgiving vacation begins
November 29, 8:10 a.m. (Mon.)
Thanksgiving vacation ends

December 21 (Tues.)
Last day of classes for Arts seniors taking Comprehensive Examinations
December 22, 10 p.m. (Wed.)
Christmas vacation begins
December 22–January 8, 1972 (Wed.–Sat.)
Comprehensive Examinations for Arts seniors

January 3–31 (Mon.–Mon.)
Graduate registration for spring semester
January 5 (Wed.)
Last day for filing applications for degrees to be granted in January
January 6, 8:10 a.m. (Thurs.)
Review–Consultation–Study period begins
Christmas vacation ends
January 7 (Fri.)
Last day for submission of Honors Theses to Thesis Advisors for January graduation
Last day for January candidates for Master's degrees to deposit with Dean of Graduate School unbound copies of thesis
January 8 (Sat.)
Review–Consultation–Study period ends
January 10 (Mon.)
Course examinations begin
January 21 (Fri.)
Course examinations end

February 1 (Tues.)
Undergraduate registration for spring semester
February 2 (Wed.)
Spring semester instruction begins
February 5 (Sat.)
ETS Language Examinations for Graduate students
February 12 (Sat.)
Last day on which registration for spring courses permitted

March 27 (Mon.)
Mid-semester reports due
March 29, 10 p.m. (Wed.)
Easter vacation begins

April 6, 8:10 a.m. (Thurs.)
Easter vacation ends
April 13 (Thurs.)
Pre-registration begins
April 15 (Sat.)
Last day for filing applications for degrees to be conferred in June
ETS Language Examinations for Graduate students
April 22 (Sat.)
Pre-registration ends
April 28 (Fri.)
Last day for June Ph.D. candidates to arrange for final examinations
Last day for June Ph.D. candidates to deliver to Dean of Graduate School approved dissertation draft

May 15 (Mon.)
Last day of classes for Arts seniors taking Comprehensive Examinations
May 16–19 (Tues.–Fri.)
Comprehensive Examinations for Arts seniors
May 16 (Tues.)
Last day of classes in spring semester
May 17 (Wed.)
Review–Consultation–Study period begins
May 18 (Thurs.)
Last day for October Ph.D. candidates to arrange for final examinations
Last day for June candidates for Master's degrees to deposit with Dean of Graduate School unbound copies of Thesis
May 19 (Fri.)
Last day for submission of Honors Theses to Thesis advisors for June graduation
Review–Consultation–Study period ends
May 20 (Sat.)
Course examinations begin
May 24 (Wed.)
Last day for June Ph.D. candidates to complete all degree requirements

June 1 (Thurs.)
Course examinations end
June 11 (Sun.)
University Day

1972-1973

August 21–29 (Mon.–Tues.)
Graduate registration for fall semester
August 28 (Mon.)
Freshmen check-in
August 28, 29 (Mon.–Tues.)
Make-up examinations and special examinations
August 30 (Wed.)
Undergraduate registration for fall semester
August 31 (Thurs.)
Fall semester instruction begins

September 8 (Fri.)
Last day for October Ph.D. candidates to deliver to Dean of Graduate School approved dissertation draft
September 11 (Mon.)
Last day for filing applications for degrees to be conferred on Founder's Day
First Faculty meeting
Last day on which registration for fall courses will be permitted
September 12 (Tues.)
Last day for October candidates for Master's degrees to deposit with Dean of Graduate School unbound copies of thesis
September 15 (Fri.)
Last day for October Ph.D. candidates to complete all degree requirements

October 2–4 (Mon.–Wed.)
Engineering Inspection Trips
October 8 (Sun.)
Founder's Day
October 30 (Mon.)
Mid-semester reports due
Pre-registration begins

November 3 (Fri.)
Last day for filing applications for degrees to be granted in December
November 4 (Sat.)
Pre-registration ends
November 6–7 (Mon.–Tues.)
Election Day holiday

November 10 (Fri.)
Last day for submission of Honors Theses to thesis advisors for December graduation
Last day for December candidates for Master's degrees to deposit with Dean of Graduate School unbound copies of thesis
November 22, 10 p.m. (Wed.)
Thanksgiving vacation begins
November 27, 8:10 a.m. (Mon.)
Thanksgiving vacation ends

December 6 (Wed.)
Last day of classes for Arts seniors taking comprehensive examinations
December 7–12 (Thurs.–Tues.)
Comprehensive examinations for Arts seniors
December 11–12 (Mon.–Tues.)
Review–Consultation–Study period
December 13 (Wed.)
Course examinations begin
December 21, 10 p.m. (Thurs.)
Course examinations end

January 2–12 (Tues.–Fri.)
Graduate registration for spring semester
January 15 (Mon.)
Undergraduate registration for spring semester
January 16 (Tues.)
Spring semester instruction begins
January 26 (Fri.)
Last day on which registration for spring courses permitted

February 19–20 (Mon.–Tues.)
February break

March 17, 1 p.m. (Sat.)
Mid-semester vacation begins
March 26, 8:10 a.m. (Mon.)
Mid-semester vacation ends
Mid-semester reports due

April 2 (Mon.)
Pre-registration begins
Last day for filing 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, 10 p.m. (Wed.)
Easter vacation begins
April 23, 8:10 a.m. (Mon.)
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 thesis
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

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 in to 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, and the engineering curricula are accredited by the Engineers Council for Professional Development.

The current market value of the endowment fund of the University exceeds forty million dollars. The value of equipment, buildings, and grounds is more than thirty-nine 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 3,300; the graduate enrollment 1,800. 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 per cent 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-seven per cent of the undergraduate student body are enrolled in the College of Engineering; thirty-three per cent in the College of Arts and Science; and seventeen per cent in the College of Business and Economics. The remaining three per cent 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, 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 receives 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. Frances 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 seletive 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 Units

The sixteen yearly courses or units required as entrance credit represent the quantitative equivalent of the usual four-year college preparatory program and include cerain prescribed subjects and sufficient electives to make up the totals listed in the following chart.

It is recommended that in addition to the minimum subject matter requirements all candidates include as many courses in science, history, mathematics, and language as their programs and schools will permit.

The recommended program for admission to all courses of study at Lehigh University includes (in secondary school grades nine through twelve) four years of English, two to four years of one foreign language (or two years each of two foreign languages), four years of college preparatory mathe-

matics, two to four years of laboratory science, and two to four years of history or social studies. These will total sixteen to twenty yearly courses or units of college preparatory study.

The statement above is the recommended preparatory program and preference will be given to candidates who present such a pattern of studies, particularly to students who have taken the opportunity to go beyond minimum subject matter requirements.

The minimum requirements for all entering freshmen are four yearly courses or units in English, four in mathematics (including algebra, plane geometry, plane trigonometry), two years of one foreign language, and six elective units (including chemistry for candidates for science, arts-engineering, and engineering).

Summary of Minimum Subject Matter Requirements (16 units)

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

*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.

Most secondary schools specify two minimum grades: one as the passing grade and the other as the recommending grade for admission to college. In the process of selective admission for Lehigh, particular emphasis is placed on the extent to which a candidate has significantly exceeded these minimum grades and has ranked high in his graduating class.

Today when more candidates apply for admission to the University than can be accommodated in the freshmen class, meeting minimum standards is not sufficient. A candidate must have shown by his school record and class rank and College Board test scores that he is well prepared to do satisfactory work at Lehigh University.

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 or January 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 activies, and established habits of industry and dependability.

Candidates are invited to visit Lehigh so that they may see the University and talk with an officer of admission. *An appointment should be made in advance of the visit.*

The most convenient hours for admission conferences are 1:30 on weekday afternoons and between 9:00 and 11:00 o'clock on Saturday mornings during the school year. The Office of Admission is closed Sundays, national holidays, Saturday afternoon during the school year, and all day Saturday during the summer months. A particularly good time for a candidate and his parents to visit Lehigh is during the summer between the junior and senior years in secondary school.

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.

Undergraduate Admission 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. In practice the University is sometimes forced to limit applications after January 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, 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, the standard freshman courses, to students who earn scores of 3 or higher. Other students, selected by the Department of English on the basis of entrance credentials, are placed in English 11. The department does not offer examinations during Freshman Orientation.

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 22, Analytic Geometry and Calculus 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 Department 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 700 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. The department usually does not offer placement tests during Freshman Orientation.

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 10, 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.

Foreign Languages. Advanced Placement and/or credit in certain reading courses to students who earn scores of 3 or higher.

The University encourages the initiative which secondary school students are showing in enrolling in advanced courses, in requesting advanced standing in college, and in assuming responsibility for a greater share of their own education. 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.

Transfer Students

Candidates for admission by transfer from other institutions may be admitted with advanced standing subject to the enrollment limitations of the several divisions of the University. Such candidates must have met the entrance requirements prescribed for undergraduates at Lehigh and must have completed at least two semesters of study at an accredited institution of higher learning.

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 the freshman and sophomore years of the curriculum he selects.

A student who desires to transfer to Lehigh University from another university, college, or junior 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 $2,450 a year for 1971–72 and $2,650 for 1972–73. 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 $103 for 1971–72 and $110 for 1972–73 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. Freshmen living away from home are required to live in residence halls for the full freshman year. 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 per cent, plus a service charge of $3 per semester, due prior to registration, 20 per cent due one month after registration, and 20 per cent due two months after registration. The $3 service charge is not refundable.

Residence Halls

About 50 per cent of Lehigh undergraduates live in University residence halls, 35 per cent live in one of thirty-one fraternity houses by invitation, and about 15 per cent live off-campus. Freshman living away from home are required to live in University residence halls for one full year.

Room rents in the residence halls range from $240 to $260 in 1971–72 and $265 to $285 in 1972–73 per semester. Maid service is included in the room fee. Rooms are rented in September on an annual lease basis only. The typical room is shared by two students.

When a candidate accepts an offer of admission to the freshman class, he is sent an application for a room in the residence halls. He is urged to return this application promptly because priority of assignment is based on date of receipt of this application, acceptance of admission, and application for admission. Thus candidates who accept offers of admission early receive preference in room assignments. Normally freshman room assignments are made in August by the Office of the Dean of Residence.

Freshmen who wish to room together should make a special request with their applications, and each student should ask his parents or guardian to submit a letter in support of the request.

Each student in the residence halls is provided with a bed, mattress, chest of drawers, desk, and chairs. Residents supply pillows, desk lamps, waste-paper baskets, blankets, quilts, and such personal items as bookends, ash trays, and radios. 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. Some students prefer to mail their laundry home in special laundry cases. Others use the laundry service made available in residence halls by a local firm at approximately $90 per year.

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 of his parents from an insurance broker or agent.

Information on off-campus housing may be secured from the office of the Director of Residence Halls.

Social Fraternities

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

Of the thirty-one social fraternities with chapters at Lehigh, twenty-six occupy houses on the campus. The remaining houses are in Bethlehem adjacent to the campus. Freshmen are "rushed" during the second 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 expense 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 $315 per semester in 1971–72 and $340 per semester in 1972–73. 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 $285 per semester in 1971–72 and $307.50 per semester in 1972–73. 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 $273 per semester in 1971–72 and $295 per semester in 1972–73. 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 $80 per semester in 1971–72 and $87.50 per semester in 1972–73. 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 of $12 in 1971–72 and $15 in 1972–73 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. To cover possible charges of this nature, all students registering for laboratory courses in chemistry purchase coupon books costing $5, the unused portions of which are redeemed.

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 $103 for 1971–72 and $110 for 1972–73 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 insitution, 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 per cent 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 per cent 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 freshman who does not live at home is required to live in the residence halls during the first year. An upperclassman who signs a lease is expected to occupy a room in the residence halls for the full college year.

An advance deposit on residence halls rooms and dining service charges of $150 will be required with the signing of the contract.

A full refund of all residence hall rentals and dining service charges paid, including advance deposits, will be made in the event a student does not register because of his involuntary induction into the armed forces or his death. A student who has paid the advance deposit but does not register for reasons other than death or involuntary induction into the armed forces will receive 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 induction into the armed forces or his death. After registration no refund of residence halls rentals or dining service charges will be made in the event of suspension of expulsion. 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 halls rental and dining service charges less $50 will be made.

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

A refund shall be certified to the Bursar by the 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-four 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.

Normally, transfer students are not eligible for consideration for assistance (grants, federal loans, Lehigh loans) from the Committee on Undergraduate Financial Aid until they have been in residence a complete academic year. Exceptions are made in the case of graduates of junior colleges, those who have completed the first three years of a 3–2 arts-engineering program, and those who are applying for majors not available at their own colleges. Transfer candidates who have been recipients of Educational Opportunity Grants or College Work-Study program funds should contact the Financial Aid Office directly. Students who are already enrolled at Lehigh and have been in residence for one college year or more are eligible to apply for financial aid.

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.

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 per cent 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 per cent 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 Educational Opportunity Grant (EOG) program, the College Work-Study Program, (CW-SP), and the National Defense Student Loan (NDSL) program. All recipients are selected by the University.

EOG 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 per cent 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 $800 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 betwen $1000–$1500 annually with low interest and deferred repayment. Applications may be obtained at participating lending institutions.

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 hall counselors come to other advisors for guidance in many areas of student life and welfare and, at all levels, academic questions, personal problems, social adjustment difficulties, financial needs, and many other troubles are dealt with daily. Problems of vocational choice and academic adjustment are not uncommon during the freshman and sophomore years.

Each student in the College of Arts and Science is considered from the begining 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 not certain about his vocational or professional choice, he needs to know both more about his own capacities and interests and more about the professions and their demands. The Counseling and Testing Service is available without charge. A large library of occupational information is there for the student's use and study. 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 conference 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 relationships 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. A staff psychiatrist is available on a part-time basis for consultation.

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 examination 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 vaccination against smallpox and 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 nurses, a night medical attendant, 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, out-patient 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 and Testing 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 debilitating emotional disturbances.

In order to obtain pertinent and objective information about the academic ability, vocational interest and social-personal adjustment of all incoming students, psychological tests are routinely administered during Freshman Week. Students are then invited in for a confidential interview during their first year in order to review their results and further evaluate and refine their thinking about their future goals. The test scores are utilized as only one of a number of sources of information important to wise and effective planning. Interpretations 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. In those cases where a student is generally uncertain, confused and unable to plan for the future with confidence, or experiencing frustration with his

studies and choice of a major, or very unhappy about his social success and his ability to get along with people, he may undertake further testing and personal counseling aimed at helping him understand his direction and motivation.

Cross communication with other University personnel agencies is maintained in gathering together information and expediting plans made cooperatively with the student. The counseling service maintains a library of educational and occupational information to which students can refer as they attempt to develop a clear conception of the educational and vocational world and their place in it. These services are available, without cost, to all University students.

The counseling service is also the administrative center of a variety of local and national testing programs in which students might be asked to participate during their college career. The most frequently administered of these programs are the Graduate Records Examinations, Law School Admissions Test, The Admissions Test for Graduate Study in Business, National Teacher Examination and Miller Analogies Tests.

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.

Reading and Study Clinic

There are many factors which influence the performance 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: including 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 arranged 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. Lehigh is one of few universities to share such policy-making responsibility with students on a one-to-one basis.

In addition to the University Forum, similar student-faculty councils exist at the college and departmental level to provide a direct line of communications in policy-setting procedures of the University.

While the board of trustees as the ultimate legal authority of the University retains authority over all transactions ofthe 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 no one need feel there is no place in which 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 Services

Varied opportunities for student expression of social responsibility exist at Lehigh through programs sponsored by the Student Volunteers' Council and the Office of the Coordinator of Volunteer Community Services. About 150 Lehigh students currently participate in volunteer service efforts in the Lehigh Valley area in fifteen different programs. The Volunteers' Council is governed by a board composed of coordinators of the various projects the Council sponsors.

Most of the volunteer work takes the form of team activities involving Lehigh in English and mathematics tutoring of school children who live in various local public housing projects, a Big Brother project, an athletic program for boys, teaching English to migrant workers, tutoring Spanish-speaking adults living in public housing projects, and assisting the county legal services for those who cannot afford private counsel. Other Lehigh student volunteer projects involve the promotion of social rehabilitation among patients at the Allentown State Hospital, assisting teachers in Lehigh's progessive elementary school, and conducting housing surveys for the city Human Relations Commission.

The Foreign Opportunities Committee of the Volunteers' Council 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, hockey 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. A special seminar in film is available to students, though the Parnassus Society and other groups feature film as an extra-curricular activity.

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, 69 kc., both broadcast throughout the day.

A student-operated coffeehouse opened in the basement of Packer Chapel recently. It seats about fifty people.

Religious Activities

The religious program is under the general supervision of the University Chaplain, who also provides for Protestant Chapel Services. Roman Catholic Services are arranged by the Chaplain to Catholic students.

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

The student-directed Interfaith Council, consisting of representatives of Protestant, Catholic, and Jewish students, coordinates the religious life program of the campus. The Council has sponsored conferences on religion, retreats, and encounter sessions on topics of concern to students. Interfaith 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, swimming, tennis, track, baseball, golf, lacrosse, and fencing; junior varsity teams in football, wrestling, basketball, swimming, and baseball; and freshman teams in most of these sports. Schedules are arranged chiefly with eastern colleges which have athletic policies similar to Lehigh's.

Normally Lehigh's athletic schedule includes four or five home football games, six or seven home wrestling meets (Lehigh's most popular sport), 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 student body, including teams from the residence halls, fraternities, classes, town, and independent groups. Twenty-three 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 and special events on the Lehigh calendar. Programs of great variety and depth are arranged by the Committee on Performing Arts, the Cleaver Founda-

tion, the Department of Music, and the music organizations of Lehigh. Recent concert series have included the Minneapolis Symphony Orchestra, the Turnau Opera Players, the Bach Aria Group, the Budapest String Quartet, The Robert Shaw Chorale, 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 James Farmer, Dick Gregory, Jonathan Kozol, Allen Ginsberg, Howard Zinn, Charles V. Hamilton, Barry Goldwater, Kurt Vonnegut, Robert Williams, and Dave Dellinger. 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, and James Reston. 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

Special Academic Programs

There is a great flexibility in undergraduate curricula at Lehigh intended to take into consideration the changing interests and needs of students. This flexibility extends to late changes of major without loss of credits. Another feature of this 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.

Alert to the increasing desire of students for courses related to contemporary social and political problems, the faculty has developed programs in urban studies, oceanography, environmental pollution control, film-making and black history.

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

In addition 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. It normally takes about one year to have a new course approved by the faculty for permanent listing in the Catalog. 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.

Most five-year, two-degree programs appear in the Description of Courses under Arts–Engineering and under 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 School 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-MBA 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.

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 further emphasize 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 Department of German conducts, 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 departments of German and Romance Languages also offer eight-week summer language and literature programs in Paris, Salzburg, and Santander, Spain. These programs provide 6 hours of credit through the Lehigh University Summer School. They are open to students from Lehigh and other institutions at the undergraduate and graduate levels.

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.

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.

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 to take "400" courses if the student has the course prerequisites and if his semester schedule does not exceed fifteen hours. (Credits from such a course can be applied toward only one degree, either graduate or undergraduate);

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 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."

Admission. Each sophomore eligible for admission to the Interdepartmental Honors Program 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 Programs 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 seminars 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 attempts 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.

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 young men, 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 candiate 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 April 15 a written notice of candidacy for the degree; candidates for graduation in February file a notice of candidacy on or before January 5; 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 class work, or two or three hours of laboratory work (or laboratory work combined with class work) 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 class work.

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 recieve 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. The grade is accompanied by a letter grade. 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 both their curriculum directors or registration advisors and with the instructors offering the courses under consideration 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 restriction 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, O. 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, and Abs. grades are not included in averages. Letter grades accompanying grades of Abs. and Inc. are computed in averages.

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 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 this section.)

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 weighed 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

Lehigh's standards of behavior are those which it regards as essential to its educational objectives and life as a community. The University relies primarily on general principles and statements of expectation for the guidance of student conduct, and it is assumed that students admitted to Lehigh are capable of governing themselves accordingly. Specific regulations are kept to a reasonable minimum and are intended to avoid unnecessary limitations that have no educational relevance. Students are advised to consult the Student Handbook for details governing applicable regulations.

Students are both citizens of society and members of the University community. As citizens, students enjoy the rights common to all citizens and have the same obligations. The University respects these rights (particularly political rights) and takes cognizance of the off-campus behavior of students only insofar as such behavior is relevant to membership in the academic community. However, the University cannot insulate itself from the community of which it is a part, and students should therefore not expect the University to afford sanctuary from the law. They should be concerned for the good name of Lehigh University, even though this consideration is not grounds for disciplinary action.

In recent years social regulations at Lehigh have been liberalized in a number of ways, and, correspondingly, there has been greater emphasis on student self-government and tradition as opposed to regulation. Thus, while there is no longer a rule requiring chaperones, it is customary for student groups to invite faculty staff, parents, alumni, and friends to social functions.

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 (minor) 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.

(3) At social functions where alcoholic beverages are available to persons over 21 years of age, non-alcoholic beverages must also be made available.

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.

Out of concern for individuality and respect for student privacy, the University does not seek to impose a common morality on all students. At the same time the University has the right to establish certain standards of conduct within the campus. Thus, an explicit standard is particularly important in the establishment of a mature and responsible code of sexual behavior. This policy is based, first, on the facts that sexual development of the individual during the college years takes place differentially and that the quality of collective life influences individual development in this regard quite significantly. The student's search for values and personal standards must take place in an atmosphere which is conducive to individual differences in development and relatively free from peer pressures. Second, the society of which Lehigh is a part generally disapproves of premarital intercourse and this is a fact to which the University cannot be indifferent. For these reasons, the University does not condone sexual intercourse in its living units (including off-campus living groups), and there is no basis at Lehigh for the presumption that privacy accords individual license without regard for the interests of others.

Abuse of the University's position will therefore be considered a violation of the interests of others and will subject offenders to disciplinary consideration.

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 in the last section 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 gymnaisum 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 hsuband, 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 humanitites and social sciences, the Rare Book Collection of 6,000 volumes, and the University Archives. Collections are particularly strong in the classics, English literature, and British colonial history. The annual acquisition rate averages about 15,000 volumes. The library receives over 4,500 periodicals and serials, including important newspapers, both foreign and domestic, and has long been a depository for a wide selection of U.S. government documents. A 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, and university publications 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 temperature thermodynamics and kinetics, analytical studies, and fine structures and metallography. The classroom wing includes an auditorium-lecture hall with a seating capacity of 225.

Maginnes Hall, a 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 for 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 departments of German and romance languages, including well-equipped laboratories. The department of music also uses the building, with rehearsal rooms for the band and glee club.

College of Arts and Science

W. Ross Yates, *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) four-year curricula in the fields of biology, geological sciences, and environmental science and resource management, leading to the degree of Bachelor of Science in the designated field; and (c) the 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, Composition and Literature. Students who are selected on the basis of superior entrance test scores will meet this requirement by passing English 11 and 12, Types of World Literature.

When a freshman completes English 11 and 12 with a grade of B or better, he is given, in addition to the six hours of credit for those courses, six hours of advanced standing credit for English 1 and 2.

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 accord with the group regulations given below. With the exception of mathematics, the student has a wide choice of courses from which to select to be used for filling 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.

Foreign Languages

The principal purpose of studying language in the College of Arts and Science is that of acquiring a means of appreciating some 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 third-year level proficiency in one language. The number of hours varies depending on the language selected and previous study in the language. Students who present at entrance four years of study in a foreign language normally are able to meet this requirement with one year of advanced college work. Two or three years of course work are normally taken by students who begin the study of a foreign language at the college level.

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

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 must 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. This program must have the approval of the College Office, which continues to supervise the non-major portion of the student's roster.

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.

Students interested in the possibility of taking a specially structured interdisciplinary major are urged to consult the Office of the Dean for information concerning proper procedure.

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, 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 selecting 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 distribution requirements.

For the specific requirements of these curricula in biology, geological sciences, 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. (These first three years of science and engineering courses constitute the Applied Science major.) During this period the Arts-Engineer is a student in the College of Arts and Science and is also working to fulfill distribution requirements for a Bachelor of Arts degree or the major requirements for one of the three science curricula. 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 impossible 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 Arts automatically fulfill the engineering general studies requirements while filling the distribution requirements of the College of Arts and Science. Arts-Engineers working towards the Bachelor of Science in biology, geological sciences, 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 Bacehlor 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 air 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, 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 military or air science are carried in addition. No more than six hours of advanced air science 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 or air science 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 some 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.

English

Students in the College of Arts and Science who persistently use poor English may be reported at any time to the Dean of the College. He may require that they undertake additional study in English without credit towards graduation.

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 Comprehensive Honors Program earlier 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.

Participation in College Governance

All students and faculty of the College are eligible to participate in the College Meeting, the principal policy making body of the College of Arts and Science. This assemblage meets several times a year and recommends proposals to the University faculty, the Forum, or other appropriate authority concerning courses, curricula, special educational programs, or other matters within the jurisdiction of the College.

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, at least fifteen 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 acquiring an 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 MBA degree in the College and in some other institutions.

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 will be found under the Description of Courses, Five-Year Programs. 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)
	or
Engl 11	Types of World Literature (3)
Engl 2	Composition and Literature (3)
	or
Engl 12	Types of World 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 45	Statistical Method (3)
Eco 129	Money and Banking (3)
Eco 206	Intermediate Micro-Economic Theory (3)
Eco 316	Intermediate Macro-Economic Theory (3)
Acctg 51	Essentials of Accounting (3)
Acctg 52	Essentials of Accounting (3)
Acctg 111	Business Data Processing (3)
Law 101	Business Law (3)
Mkt 211	Marketing (3)
Fin 225	Principles of Corporation Finance (3)
Mgt S 302	Quantitative Models–Conceptual (3)
	or
Mgt S 321	Business and Organizational Behavior (3)

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

Accounting majors must take Mgt S 302.

Major Program

Before the end of the second semester of their sophomore 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.

Optional Courses (33 credits)

Language Option (12 credits)

Except for the requirement of two high school units in one foreign language for entrance credit, students in the college are not required to take work in foreign languages. Foreign Careers majors, however will take at least 6 hours in an appropriate foreign language specialty beyond the elementary course. Credit for less than six hours in an elementary language will not be accepted in partial satisfaction of this option.

All courses offered by the department of English which require work in composition, either oral or written, or a study of literature will be accepted in satisfaction of the language option requirement. Journalism courses which do not require work in composition or study of literature will not be accepted. One-hour courses in speech and journalism will not be accepted for the language option requirement but may be counted toward electives.

Other Arts Options (12 credits)

The arts requirement of twelve (12) hours must include at least six (6) hours drawn from departmental offerings in government, history, international relations, psychology, social relations, and philosophy. The remaining six (6) hours may be taken in courses offered by any of the above departments or in fine arts, classical languages, mathematics, music, philosophy, and religion. One-hour courses in music will not be accepted for the arts option but may be counted toward electives.

Science Option (9 credits)

The science requirement of nine (9) hours must include at least six (6) hours from one or a combination of two of the following fields: biology, chemistry, geological science and physics. The remaining three (3) hours may be devoted to a field named above or may be taken in astronomy, mathematics, philosophy or psychology.

Note that the same course may not count for credit against more than one option requirement even where the same field is listed under different options.

Electives (20 credits)

Normally any courses in the University for which a student has the prerequisites may be used as electives as long as such courses carry University credits. Advanced military science and aerospace studies courses may be counted as electives up to 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 science and arts option requirements 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 spring pre-registration in his sophomore 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, language option, other arts option, and science option 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 MA-MS 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. Normally, two years are required to complete the M.B.A. degree. 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	Business Data Processing (3)
Eco 45	Statistical Methods (3)
Mgt 302	Quantitative Models—Conceptual (3)
	or
Mgt 314	Operations Analysis (3)

Functional and Organization Studies

Fin 225	Principles of Corporation Finance (3)
Mkt 211	Marketing (3)
Mgt S 321	Business and Organizational Behavior (3)

Economic and Legal Environment

Eco 129	Money and Banking (3)
Eco 206	Intermediate Micro-Economic Theory (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.

A procedure of advanced placement by examination permits exemption of individual courses listed above where a candidate has had prior preparation in a field and establishes his proficiency by passing an approved examination at a satisfactory level of performance in the subject. Candidates are given schedules for these examinations upon admission to the program. 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 MBA program.

Required Advanced Courses (15 hours)

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

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

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

Electives Courses (15 credit 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 to 12 hours in a field 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.

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 of the college 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 to a variety of professions, or graduate study in medicine, government, law or management. The college encourages such mobility. Experience shows that "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 theoretical and experimental areas. Senior year programs in the sciences can be planned to facilitate transition to either graduate school or industrial laboratories.

Undergraduates with interests in such 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. Graduate study in such areas can best be implemented by mastering science and engineering fundamentals and combining these with appropriate related electives.

The freshman choice of a specific curriculum may be changed prior to the sophomore year without loss of time. Within 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 pre-registration 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 without having to make up courses as late as the end of the sophomore year. There are instances, however, where such a transfer will require one or two courses to be taken during Summer Session.

Since the University 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, the degree awarded upon graduation is Bachelor of Science in the particular division of engineering.

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.

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 several specialized curricula under Description of Courses.

Freshman Year, First Semester (12 credit hours)

Engl 1	Composition and Literature (3)
Chem 21, 22	Introductory Chemistry Principles & Lab
	or
Phys 10, 11	Introductory Physics I & Lab (5)
Math 21	Analytic Geometry & Calculus (4)
Engr 1	Introduction to Engineering Problems
	or
	Social Science GS Elective (3)

Freshman Year, Second Semester (15 credit hours)

Engl 2	Composition and Literature (3)
Phys 10, 11	Introductory Physics I & Lab
	or
Chem 21, 22	Introductory Chemistry Principles & Lab (5)
Math 22	Analytical Geometry and Calculus II (4)
Engr 1	Introduction to Engineering Problems
	or
	Social Science GS Elective (3)

Note: English 1 and 2, Composition and Literature, are the courses normally taken in the first and second semesters of the freshman year. Students who demonstrate superior ability will be offered registration in English 11 and 12, Types of World Literature.

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 elect a three-year social science course from the General Studies Listing (Group II) as an alternative.

General Studies

General Studies (GS) are non-professional, non-specialized studies in the large areas of human knowledge and experience with which any educated man should be acquainted. These areas are: the humanities, social sciences, and the natural sciences. Since all students in the college are expected to complete specified sequences of courses in the physical sciences, the general studies program is restricted to the humanities, the life and earth sciences, and the social sciences.

The General Studies sequence starts in the freshman year with six hours of English composition and literature and three hours of social science. During the following six semesters, nineteen additional hours (six courses) are elected so that by the end of the senior year, a student will have completed a minimum of twenty-eight 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 satisfy General Studies objectives.

The distribution requirements of General Studies are as follows:

Group I: Humanities (9 hours minimum)

Literature (English or American)

Freshman English, 6 semester hours (University requirement). English 1 and 2, Composition and Literature. Students who complete the alternate courses English 11 and 12, Types of World Literature, will have met this requirement; those who complete English 11 and 12 with a grade of "B" or better will automatically be granted General Studies credit for English 1 and 2 as well as for English 11 and 12, for a total of 12 hours. Any English literature course beyond the basic 6 hour requirement may be taken to fulfill the minimum.

Literature (Classical)

Gk 50	Greek Literature in English Translation (3)
Lat 51	Latin Literature in English Translation (3)

Literature (Foreign Language)

Any literature course in a foreign language (i.e. must be beyond intermediate level).

Communication

Speech 30	Fundamentals of Speech (3)
Speech 32	Conference and Discussion (3)

Foreign Language

Any language course on the intermediate or elementary level, classical or modern. (If elementary language study is elected, a minimum of six hours must be in one language in order to receive General Studies credit. A student may not elect for elementary study any language in which he has entering credit.)

Fine Arts

Music 20-32	(any course)
FA	(any course)
Speech 61	(dramatics)

Philosophy and Religion

Phil	(any course)
Religion	(any course)

Group II: Social Sciences (7 hours minimum)

Eco 1	Economics (Required) (4)
Eco 129	Money and Banking (3)
Eco 206	Intermediate Micro-Economic Theory (3)
Eco 303	Economic Development (3)
Eco 307	History of Economic Thought (3)
Eco 308	History of Economic Thought (3)
Eco 309	Comparative Economic Systems (3)
Eco 316	Intermediate Macro-Economic Theory (3)
Eco 335	Manpower Economics (3)
Eco 336	Business and Government (3)
Eco 338	Labor Market Institutions (3)
Eco 339	International Trade (3)
Eco 340	International Finance (3)
Eco 353	Public Finance, Federal (3)
Gk 21	Ancient History (3)
Gk 202	Greek Archaeology (3)
Lat 22	Ancient History (3)
Lat 203	Archaeology of Italy (3)
Govt	Any Course
Hist	Any Course
IR	Any Course
SR	Any Course

Group III: Life and Earth Sciences (No minimum)

Astron 1	Descriptive Astronomy (3)
Astron 104	Stellar Astronomy and Astrophysics (3)
Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Laboratory (1)
Biol 28	Genetics (3)
Biol 34	Comparative Vertebrate Anatomy (4)
Biol 35	Microbiology (3)
Biol 306	Ecology (3)
Biol 320	Physiology (3)
Geol 1	Principles of Geology (3)
Geol 12	Historical Geology (3)
Geol 311	Paleontology (3)
Geol 363	Introduction to Oceanography (3)
Psych 3	Psychology as a Natural Science (3)
Psych 4	Psychology as a Social Science (3)
Psych 111	History and Systems (3)

Graduation Requirements

A student in good academic standing earns his degree by meeting the requirements of his specific degree program 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. Each student is expected to satisfy the credit hour requirements for his curriculum. Basic military science credit hours are in addition to the credit hours specified by the curriculum. The student is encouraged to confer with his curriculum advisor on all matters related to his program.

Honors Programs

Outstanding students in the college may participate in the Comprehensive Honors Program. Each department offers honors work, with some differences in detail to adapt to the specific needs of the department.

Outstanding students may receive permission to do independent study on an unscheduled basis, thereby proceeding more rapidly and more deeply than is possible in regularly organized classes. This permits the student who is qualified for and interested in this

work to proceed in a direction agreed upon with his 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 the various curricula in engineering. 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.

Cooperative Programs

Lehigh University has entered into agreements with certain industrial organizations whereby undergraduate students in various branches of engineering may pursue an interleaved course of study and industrial employment, comprising eight terms of study at Lehigh University, and two periods (each approximately equal to a term) of employment in industry, totaling four calendar years, at the successful completion of which the student will receive a B.S. degree from Lehigh University and a suitable certificate from the industrial concern.

The objective of a cooperative program is to give the student an opportunity to become familiar with industrial methods, policies, and environment, to the end that he will acquire a greater degree of motivation in his academic studies.

The scope of the academic part of a cooperative program is identical with that of the standard curriculum in which the student is registered. Exactly the same courses are taken and in substantially the same sequence.

The first industrial employment period commences at the end of the sophomore year. The degree is conferred upon the completion of the senior year. Students electing a cooperative program are expected to complete it.

During the two periods of industrial employment the student is closely supervised to guarantee that he acquires a balanced training in industrial practice. Representatives from the University make periodic inspections of the industrial training part of the program for the purpose of assuring that this training is in keeping with the above objectives and that the student is receiving maximum benefits from the cooperative program. The student is required to render a comprehensive report on his observations and work while employed in industry.

While engaged in industrial employment the student is paid at prevailing rates for the type of work in which he is engaged.

There is no obligation, either legal or moral, on the part of the student to agree to accept permanent employment with the industrial concern which sponsors his cooperative program; nor is there any obligation on the part of the industrial concern to offer him permanent employment.

The details of cooperative programs vary with different curricula and industrial organizations. Interested students should consult their curriculum directors. A typical four-year program between Electrical Engineering and the sponsoring company, which comprises ten approximately equal periods, is as follows:

1. Freshman I—First Semester
2. Freshman II—Spring Semester

Vacation—Summer Semester

3. Sophomore I—First Semester
4. Sophomore II—Spring Semester
5. Company Work—Summer Semester
6. Junior I—First Semester
7. Company Work—Spring Semester
8. Junior II—Summer Semester
9. Senior I—First Semester
10. Senior II—Spring Semester

Note: During Period 7, while the student is with the sponsoring company, a course in Electronic Circuits (E.E. 105) is taught on the company premises.

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. The fifth year is spent in the College of Engineering, carrying on a program leading to the degree of B.S. in his

selected branch of engineering. This is usually the senior year curriculum of the chosen branch of engineering.

An engineering student who decides at any stage of his course that he wishes to work for both the B.A. and B.S. degrees, may register in one of the colleges concerned for a period of years and complete the combined requirements of both degrees in five or six years, depending upon the program followed before the decision is made. His curriculum is so arranged that the work for one degree may be finished at the end of a four-year period and the work for the subsequent degree at the close of the fifth or sixth year. For further information, see the Description of Courses.

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 mechanics, biology, business and economics, chemical engineering, chemistry, civil engineering, economics, education, electrical engineering, English, geology, government, history, industrial engineering, information sciences, international relations, 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, Latin, German, French, and Spanish, 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 mechanics, biology, business and industrial economics, chemical engineering, chemistry, civil engineering, 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

Education 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 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 prejudice in any way 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 September 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 $1150 per semester or $96 per semester hour for 1971-72, and $1,287.50 per semester or $108 per semester hour for 1972-73, whichever amount is lower. A listener's fee of $96 for 1971-72 and $108 for 1972-73 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 per cent plus a service charge of $3 per semester, due prior to registration; 20 per cent due one month after registration; 20 per cent 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 $500 per semester or $41 per semester hour in 1971-72 and $600 per semester or $50 per semester hour in 1972-73, whichever is applicable.

To qualify for the doctorate, all students must pay tuition fees equivalent to three full years beyond the bachelor's degree or two full years beyond the master's degree. Until these fees are met, resident doctoral candidates must pay a minimum registration fee of $300 each semester and summer period. Thereafter doctoral candidacy must be maintained by a registration fee of $100 per semester and summer period.

Doctoral candidates registering for dissertation should indicate credit hours corresponding to the tuition paid (calculated at $96 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 per cent of this tuition for each full or fractional week of the semester computed from the date of the beginning of instruction in courses open only 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 4 per cent 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 June file with the Registrar, on a form provided for the purpose, on or before April 15, 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 January must file on or before December 15. 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 be done in actual and regular 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 graduate work submitted for 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 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.

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 consideration the application'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 May 1, if the degree is to be conferred in June; not later than September 1, if the degree is to be conferred in October, not

later than December 1 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 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 research 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 Computer 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

Most resident graduate students live in rooms or

apartments near the campus, although from time to time a limited number of living accommodations is available in the undergraduate Residence Halls on the University campus.

The Graduate School cannot assume responsibility for locating housing. A number of rooms and apartments are available in private residences. Since accommodations are scarce, the student is advised to arrange for housing well in advance of his beginning residence.

Inquiries in regard to accommodations for graduate students, either married or single, can be directed either to the Director of Admission or to the Bureau of Housing Information, Lehigh University.

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. During the past year, 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 Sessions

During the summer the University offers several programs for undergraduate and graduate students: two sessions of five weeks each; several workshops in education; special engineering courses in surveying and machine shop; and two reading and study development laboratory programs—one for high school students and the other for college entrants.

In addition to 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—scholarhips, 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, many 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 student.

Appointment to these fellowships is for a period of two semesters and may be renewed, provided the work of the holder is of such quality as to justify

continuation of financial aid. Usually the research work can be used for thesis or dissertation.

Annual stipends for most fellowships are $1800 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. Several 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 $2500 ($2750 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. 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. Often, 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 $800 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 trainee-

ship 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 chairman of the department, the Office of Admission, and the Graduate School Office. Available loan funds include:

National Defense 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 per cent 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 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 per cent 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, administrators, reading specialists, curriculum specialists, research specialists, and specialists in the foundations of education. 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 two semesters of full-time study, students have met the requirements to begin teaching. After the completion of one semester of full-time teaching, they meet the 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. The academic fields which now cooperate with the School of Education in offering this degree include: classical languages; mathematics; English; romance languages; German; 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, guidance and counseling, and reading. 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 in 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 students 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 superintendendency, community college teachers.

Division of Counselor Education

John A. Mierzwa, *Director*
guidance counselor, school psychologist, counseling.

Division of Elementary Education

Alfred J. Castaldi, *Director*
elementary teachers (interns), elementary master teachers, reading.

Division of Secondary Education

Robert L. Leight, *Director*
secondary school teachers (interns), secondary master teachers, educational foundations.

Division of Educational Measurements and Research

Paul Van Miller, *Director*

Research Centers and Organizations

Currently, eight interdisciplinary research centers and three 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 pertinent to regional and national progress.

The research centers, institutes, and research related organizations are administratively responsible to the Office of the Vice President—Research.

Research Centers

Center for Surface and Coatings Research

The purpose of the Center for Surface and Coatings Research, which was established in 1966, is to encourage faculty and students from all pertinent disciplines to undertake research relevant to surface and coating phenomena. Present and potential graduate students are encouraged to explore the availability of research support and financial assistance with the director.

The center fulfills its purpose by providing opportunities for research and education, for the most part at the graduate level. Personnel now engaged in the program include thirteen faculty members, four research associates and graduate students from the departments of chemistry, chemical engineering, mechanical engineering and mechanics, metallurgy and materials science, and psychology. Participation of students from the departments of physics and biology is being encouraged.

The research program emphasizes solid/gas and solid/liquid interactions. Techniques being pursued in studies of the solid/gas interface include: electron spin resonance, ferromagnetic resonance, Auger spectroscopy, Mossbauer spectroscopy, adsorption of radiotracers, flash filament desorption, infrared reflectance spectroscopy, and ellipsometric studies of surface films. A major effort is concerned with the mechanism by which structurally important metals corrode, lose strength, and fracture under cyclic or constant stress in different environments.

The solid/liquid studies are concerned particularly with processes related to the formation of chemical coatings. Many coatings are based on colloidal dispersions of pigments in polymeric fluids. The work is focused on the mechanism of deaggregation and stabilization, effects of polymer orientation and other adsorbed species on interfacial properties, rheological response under stress, and adhesion to and flow into porous substrates. Ceramic coatings, such as silicon nitride, are being studied as protective coatings on metals. Research on color and colored coatings is carried out within the Color Science Laboratory. Current research focuses on computer color matching, metamerism, and color constancy under different viewing conditions.

Other research involves the surface properties of ice nucleants, electrodeposition, environmentally induced metal fatigue, pollution of streams by solids and resultant properties, interfacial properties of detergents, gas and vapor adsorption, heats of immersion, metal/water systems, wetting phenomena, non-soap lubricants, and surface properties of polymeric coatings.

A liaison program involving government and industry is conducted whereby fundamental, non-proprietary research, in an area of specific interest to the participant organization, is carried out by CSCR staff and graduate students.

Short courses, generally held during the summer, are offered in surface science, printing ink technology, and color science.

Computing Center

Located on the first floor of 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 system. This system consists of 65,536 (60 bits/word) words of storage, ten peripheral and control processors, each with 4096 words (12 bits/word), 969 million characters of disk storage, 4 magnetic tape units, 1200 cards-per-minute card printers, incremental plotter, remote entry display terminals and teletypes. The principal programming languages used with the large library of programs are Fortran IV, Fortran Extended, Cobol, and Compass (assembler).

Seminars are held or sponsored by the center for faculty , staff and graduate students on varied subjects relating to data processing. The center conducts a Computing Associates Program which provides Lehigh faculty computing expertise in meeting the needs and problems of industry and government. The center also operates an inquiry service for consultation. A Users Area is provided containing teletypes, key-punch machines and reference materials.

Computer-Oriented Courses

The University has a traditional, strong commitment to mathematics, engineering and pure and applied science. Although the University does not offer undergraduate and graduate degrees in the fields of computer science and computer engineering, numerous courses exist in academic departments which make it possible to arrange a concentration of computer-oriented courses within an existing degree program. These courses, which are listed below, cover a broad spectrum including computer circuitry and organization, programming and computer languages, computer-oriented mathematics including logic and numerical analysis, and a variety of computer applications areas. Students with a strong interest in computing are encouraged to discuss the courses at the undergraduate and graduate level with one of the existing academic departments.

Undergraduate

Acctg 111	Business Data Processing
CE 101	Computer Methods
EE 11	Introduction to Computer Engineering
EE 201	Computer Architecture
EE 205	Pulse and Digital Circuits
EE 241	Switching Theory
Geol 10	Computer Applications
IE 18	Information Processing Theory
Math 105	Computer Programming
Math 230	Numerical Methods
Math 243	Algebra
Math 244	Algebra
Math 251	Mathematical Methods
Math 252	Mathematical Methods
IS 201	Computers and Language
IS 202	Computers and Society

Advanced Undergraduate and Graduate

Acctg 311	Accounting Information Systems
Acctg 408	Management Information Systems
CE 408	Computer Methods in Civil Engineering
Ed 381	Educational Systems and Information Processing
Ed 458	Statistics IV
Ed 459	Methods of Statistical Inference and Research Design
EE 311	Compiler Design
EE 321	Current Topics in Magnetics
EE 342	Communication Theory
EE 373	Mathematical Methods in Information Science (IS 373, Math 373)
EE 401	Digital Systems
EE 403	Design of Executive Systems
EE 411	Information Theory I
EE 412	Information Theory II
EE 415	Pattern Classification Theory and Applications I
EE 416	Pattern Classification Theory and Applications II
EE 431	Topics in Switching Theory
EE 432	Finite and Infinite State Machines
EE 435	Coding Theory
Geol 320	Advanced Computer Applications
IE 307	Information Systems Engineering
IE 309	Data Processing Systems

IE 310	File Structure and Processing
IE 408	Management Information Systems
IE 418	Simulation
IE 437	Information Systems Seminar
IE 438	Real Time Information
Math 322	Methods of Applied Analysis I
Math 323	Methods of Applied Analysis II
Math 331	Numerical Analysis
Math 333	Difference Methods in Partial Differential Equations
Math 362	Computer Languages (IS 362)
IS 321	Introduction to Retrieval Methods
IS 350	Applications of Non-Numerical Automata
IS 374	Information Retrieval Theory
IS 380	Library Automation
IS 422	Analysis of Information Systems
IS 432	Mechanized Subject Document Retrieval
IS 442	Evaluation Models

Fritz Engineering Laboratory

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 Frtiz 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.

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.

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. Through their work in research programs, men are trained for careers in teaching, in research, and in advanced engineering design.

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 publication of papers in technical journals both in this country and abroad.

Center for Information Science

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 both as a development made possible by advances in computer technology. Although they are not identical, information science and computer science are so closely related as to cover essentially the same activities in science and engineering, and this parallelism is reflected in the structure of research and education in the Center for Information Science at Lehigh.

The nature of information and the processes by which it is communicated are basic to the study of information science. This study includes investigation of the origin, dissemination, collection, organization, storage, retrieval, interpretation, and use of information. The Center for Information Science supports ongoing research projects into all of these problems, and contributes substantially to the educational program in information science, established as a division of the philosophy department in 1964. In both research and instruction, considerable emphasis is place 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, which has a tripartite structure of (1) theory of information, (2) theory of the information process, and (3) theory of information systems. Courses in information science are listed under the Division of Information Science.

The physical facilities of the Center for Information Science include: a fully-equipped information laboratory in the Mart Science and Engineering Library, with offices and seminar room; offices in the Linderman Library and the Philosophy Building. The center is working closely with the Mart Library in the development of a fully automatic, on-line, conversational information system known as *Leadermart*. The *Leadermart* system will provide the interdisciplinary research centers with remote, on-line access via cathode ray tube display terminals to a large data base of scientific documents stored on the CDC-6400 computer. By means of this service, workers in the research centers will be able to negotiate inquiries and to 'browse' the data base without leaving their offices. Current awareness capabilities are also available such that researchers may have current scientific literature scanned for topics of interest to them as it is published.

Center for Marine and Environmental Studies

The Marine Science Center, established at Lehigh in 1962 with staff and graduate students from the departments of biology, chemistry and geology, was expanded in 1968 to include ocean engineering and environmental studies under the name, The Center for Marine and Environmental Studies. As an interdisciplinary research organization, CMES provides opportunities for research in problems of common interest for students and staff from several departments.

The center is a research organization rather than an academic department of the University: graduate students are normally enrolled in traditional departments where courses are taught and graduate degrees are granted. However, interdisciplinary graduate degree programs are being developed, to be administered by a special interdepartmental committee: students under these programs will not have to be enrolled in or meet the curriculum requirements of a traditional academic department. Additional information on these interdisciplinary graduate degree programs is available upon request to the center. No undergraduate degrees are offered in marine science, ocean engineering, or water pollution control. Graduate degrees (M.S. and Ph.D.) are awarded in traditional academic departments. Graduate options or minors are being developed in marine science, ocean engineering, and water quality control.

Research is emphasized at all levels of graduate study. There are many opportunities for beginning graduate students to cooperate with the staff on laboratory and field studies. Advanced students are encouraged to undertake independent and interdisciplinary research problems.

Much of oceanography and ocean engineering is learned by actually doing research in the marine environment. Although Lehigh is an inland university, the staff and students of CMES have a wide variety of opportunities to work at sea through arrangements

with other oceanographic institutions.

Cooperative programs are active with Woods Hole Oceanographic Institution, the Atlantic Oceanographic Laboratories of NOAA (Miami), Texas A & M University, Duke University, the Sandy Hook Laboratory of the U. S. Bureau of Fish and Wildlife, Scripps Institution of Oceanography, the University of Delaware, and the Coast Guard.

Environmental studies are also best learned by doing research in the field. Air pollution studies are carried out in conjunction with the Lehigh Valley Council for Clean Air. Long term water quality and pollution studies are active on the Lehigh and Delaware Rivers. CMES is an active member of a multi-institution consortium, the Institute for Development of Riverine and Estuarine Systems (IDRES), with numerous research projects on the Delaware River, Estuary and Bay, funded by the Pennsylvania Science and Engineering Foundation, the National Science Foundation, the Water Quality Office and other state and federal agencies.

Off campus, a new seaside research and education facility will be operated by Lehigh University and CMES. Scheduled for completion in October 1971, the South Jersey Wetlands Institute at Stone Harbor, N. J. will include a museum and display area, a research laboratory wing, and a dormitory for resident students and faculty. Research programs are being developed in coastal salt marsh ecology, and estuarine and near-shore sedimentary processes. Summer courses will be offered beginning in 1972. For more information, write Dr. Sidney S. Herman, Professor of Biology and Director of the South Jersey Wetlands Institute.

Current research activities of CMES staff and students include: marine microbiology and biochemistry of proteolytic marine bacteria; geotechnical properties of oceanic sediments; biological effects of thermal pollution; coastal salt marsh environmental studies; shallow water near shore and estuarine sedimentation; crustacean physiology; fluorescent antibody fish egg identification; pedology of Enderby Land, Antarctica; mathematical modeling of ecological, chemical and physical systems of streams and lakes; and pollution studies of various local streams.

The on-campus facilities of CMES include: the Marine Biochemistry Laboratory for microbiological and biochemical research; the Marine Biology Laboratory with temperature-controlled circulating artificial salt water aquaria; the Marine Geotechnical Laboratory; the Sanitary Engineering Laboratory for studies in water quality control; and the Institute for Pathobiology.

The Marine Geotechnical Laboratory consists of over 5,000 sq. ft. of staff and student offices, laboratories, a conference room, and a heavy equipment assembly room. Specialized facilities include a nondestructive testing laboratory, a geotechnical geochemistry laboratory, a walk-in core refrigerator, a hydrostatic pressure testing chamber, a programmable electronic calculator, a dark room, a technical library, an electronics laboratory, and a machine shop. The geotechnical laboratory possesses equipment especially modified or constructed for the shear strength and consolidation testing of very soft and cohesive seafloor soils. Major emphasis is placed on geotechnical measurements at sea from ships and submersibles. MGL personnel have pioneered the inplace measurement of shear strength, bulk density, and pore pressure—using a vane probe (to a water depth of 3.6 km or 12,000 ft.) a cone penetrometer probe, a nuclear transmission densitometer probe and a differential-pressure piezometer probe. Specialized coring equipment exists for quality sampling to any water depth.

Current projects include: establishing geotechnical test areas in the San Diego Trough and in the Gulf of Maine using submersibles and ships in cooperation with Lockheed Ocean Laboratory, NOAA, Coast Guard, Woods Hole Oceanographic Institution, and Scripps Institution of Oceanography; developing geotechnical instrumentation for use on large and small submersibles; studying the vertical and areal geotechnical properties of the Gulf of Mexico by in-place measurements and by cores in cooperation with Texas A & M University; analyzing extensive geotechnical data of the Oslofjord, Norway, collected by the Norwegian Geotechnical Institute; investigating the consolidation of sea-floor soils by consolidometer testing and by sedimentation-compression curves constructed from results of nuclear densitometry; preparation of bibliographies on coring, mass physical properties of deep-sea soils, and ocean engineering books; improving methods of geotechnical data reduction and presentation and subsequent statistical data analysis using a CDC 6400 computer

and a Calcomp 563 plotter.

Marine Science and Environmental Study Courses

Marine Science and Ocean Engineering

Biol 417	Marine Ecology (3)
Biol 418	Biological Oceanography (3)
Biol 480	Marine Science Seminar (3)
Chem 3xx	Chemical Oceanography (3)
CE 328	Channel and Oceanographical Hydraulics (3)
CE 332	Introduction to Ocean Engineering (3)
CE 333	Ocean Engineering Field Investigations (1-3)
CE 381	Special Topics (3)
CE 425	Mechanics of Sediment Transport (3)
CE 431	Geotechnical Ocean Engineering (3)
CE 439	Ocean Engineering Research (1-6)
Geol 363	Introduction to Oceanography (3)
Geol 418	Sedimentary Petrogenesis (3)
Geol 461	Marine Geology (3)
Geol 490	Special Topics (3)
ME 323	Fluid Mechanics of Ocean and Atmosphere (CE 324) (3)
Phys 3xx	Physical Oceanography

Environmental Studies and Water Quality Control

Biol 306	Ecology (3)
Biol 309	Aquatic Biology (3)
Biol 361	Sanitary Microbiology (3)
Biol 414	Advanced Ecology (3)
ChE 320	Waste Water Control (3)
ChE 321	Fundamentals of Air Pollution (3)
Chem 310,311	Instrumentation Principles (3, 3)
Chem 371	Elements of Biochemistry (3)
Chem 372	Advanced Biochemistry (3)
Chem 397	Colloid and Surface Chemistry (3)
CE 326	Ground Water Hydrology (3)
CE 371	Environmental Health Engineering (3)
CE 424	Surface Water Hydrology (3)
CE 471	Water Treatment Facilities (3)
CE 472	Water Pollution Control Facilities (3)
CE 475	Advanced Topics in Water Resources (3)
Eco 311	Economics Resource Use (3)
Geol 211	Environmental Planning (3)
Geol 398	Special Problems in Environmental Science (3)

Materials Research Center

Materials research has played an important role at Lehigh for the past two decades. 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. 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 education opportunities.

To achieve these objectives, the center coordinates and integrates all activities pertaining to materials science and technology at Lehigh University; seeks to establish a climate in which faculty members, post-doctoral associates, and graduate assistants develop an awareness of materials; arranges for facilities and space required to conduct interdisciplinary research; guides the search for new materials by encouraging fundamental research and new approaches to materials problems; assists in developing educational opportunities in materials, in particular, interdisciplinary graduate programs devoted to training for research in materials; and conducts the Materials Liaison Program with industry and government.

The activities and programs of the Materials Research Center are guided by a Materials Council composed of senior faculty members from all of the engineering departments as well as from the Department of Geological Sciences. The policies and decisions of the Council are implemented by the Director of the Center and his staff.

The present organization of the Materials Research Center, located at the Coxe Laboratory, includes 4 laboratories: Advanced Materials Laboratory, Mechanical Behavior Laboratory, Polymer Laboratory, Physical Ceramics Laboratory, and three service laboratories: the Electron Microscopy Laboratory, the Physical Measurements Laboratory, and the Materials Clean Room.

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.

The center, from its beginning, has emphasized a coupling approach to materials research, recognizing the mutual intellectual stimulation of scientists and engineers dedicated to a common problem. A logical outgrowth of this approach is the Materials Liaison Program, initiated in 1963. 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. thesis abstracts on materials research; and monthly seminars with outstanding invited speakers.

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. 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 may pursue course work related to a fundamental understanding of materials in several disciplines and conduct research on a broad materials problem involving several graduate students from different disciplines.

For further information concerning course offerings in materials, see the description of the B.S. Engineering–M.S. Materials Program and course offerings in materials.

Financial support for graduate students is available through the Materials Research Center by means of industrial fellowships, fellowships provided from the operating funds of the center, research assistantships related to sponsored research programs, and by various government traineeships and fellowships.

Current interdisciplinary research activities include:

Advanced Materials

Characterization of metal oxide films.

Defect structure of amorphous and crystalline silica and silica thin films.

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.

Solidification of tool steels.

Structure and properties of sputtered, evaporated, and plated thin films.

Mechanical Behavior

Electron fractography (scanning and replica)

Effect of stress state and load history on fatigue crack propagation.

Influence of welding on fatigue characteristics of weldments.

Mechanical behavior of eutectic composite materials.

Fatigue of polymeric materials and adhesive joints.

Fracture of bridge steels.

Low-cycle fatigue.

Physical Ceramics

Sintering mechanisms

Press forging (compressive deformation)

Synergetic hot forming

Processing behavior of alumino-silicate ceramic materials

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.

Center for the Application of Mathematics

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.

In addition to the research and the support of teaching already described, the activities of the center include the sponsorship of a colloquium, of lectures which report current research on the campus, and of expository lectures.

The center serves in an advisory capacity on interdepartmental graduate programs, both in the design of programs to suit the interests of students and departments and in making recommendations on the award of fellowships and assistantships.

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.

The center sponsors institutes and conferences. It seeks support through contracts and grants for interdepartmental research related to the application of mathematics.

The center is concerned with the imaginative use of computing facilities.

Center for Business Economics and Urban Studies

Business economic activities were initiated in 1965 when the Business Economics Center was formed at Lehigh University with the purpose to apply economic analysis to business problems, and carry out research linking business behavior and policy with economic analysis and investigation.

In April 1968, with the University's recognition of the need for a formal research program in urban studies, the functions and name of the center were expanded to the Center for Business Economics and Urban Studies. With the addition of urban studies, the center continues to pursue the initial objectives; but in addition and in conjunction with these goals, seeks to focus on the important issues of the urban area and bring together the resources of relevant disciplines in order to stimulate discussion and encourage urban studies. It provides liaison among educational institutions, industrial and other community groups and government agencies which are concerned with urban problems. The center is intended to promote integration of business, economic, and urban studies to attract able scholars and superior graduate students to Lehigh, and initiate and provide the basis for expansion of research of such integrated character.

Inquiries of businessmen, government officials and others in the field are invited. Research programs are organized where appropriate and professional experts are utilized when that course appears promising. Research fellowships are available to a limited extent to attract students who are desirous of working on the research problems which arise.

Graduate students in the center may receive the M.S. in Business Economics or an M.A., concentrating on Urban Studies in a traditional discipline such as economics, history, government, or social relations.

Basic research in the center relates to plant and equipment forecasting models, housing analyses, urban design, regional transportation systems, political structure, and social processes that take place within urban areas.

Institutes

Institute of Fracture and Solid Mechanics

The Institute of Fracture and Solid Mechanics was established in the fall of 1970 to enable faculty members and students within the University to participate in research relevant to fracture and solid mechanics on a unique, interdisciplinary basis. It is organized to create a large pool of facilities and skills for promoting graduate research and training. The

members of the institute can hold appointments in the various departments and research centers but serve the University as a whole.

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 so that the research materials can be synthesized and made available in a coherent fashion to the reader in a relatively short period of time; 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; interaction with faculty and students to encourage research in areas related to fracture and solid mechanics.

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.

Glassy-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 polynomials.

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.

The Institute for Pathobiology

The Institute for Pathobiology, a branch of the Center for Marine and Environmental Studies, is an interdisciplinary unit involved with research, and research related post-doctoral and graduate education. Fields currently represented in on-going research projects include virology, microbiology, protozoan and metazoan parasitology, invertebrate pathology, immunology, biological control, biochemistry, medicinal chemistry, 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, histochemical, immunological, physiological, biochemical, and tissue culture studies. Studies on the diseases of marine and estuarine fishes and shellfishes are being conducted in conjunction with the University's Marine Laboratory.

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; synthesis of aminoquinolines and amodiaquine analogs as potential antimalarial and antitrypanosomal compounds; development of efficient molluscicides for the control of vectors of schistosomiasis and fascioliasis; study of viral diseases and virus induced tumors in fishes; study of the effects of pollution (thermal, chemical, and biological) on marine and freshwater organisms.

Institute for Metal Forming

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.

The results of these studies are available in the scientific and technical literature. In addition, an important part of the effort of the institute is devoted to preparing educational programs reporting on these studies by the latest audiovisual techniques. These programs are used in the classroom and in institute-sponsored seminars on campus and at industrial facilities.

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.

Long-range planning and activity, together with major equipment acquisitions and construction, are supported by University funds, federal funds, and an industrial consortium group. Interested industrial concerns participate through a consortium program involving an annual grant. An advisory committee guides the activities of the unit, and the participants have access to the following services: all research reports resulting from the grant program and from other specific studies forwarded promptly to consortium members; full day seminars, offered twice per year where the latest research results are reported; a limited amount of consulting, available to each grantor, through a visit to Lehigh or to the grantor's plant; limited access to laboratory facilities, possible for exploratory or preliminary experimental studies; participation in the advisory committee, for the purpose of choosing new directions for research.

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, by fostering research in the field of educational practice, and by 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.

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.

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.

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 proper officers have so evaluated this preparation previously.

English 2 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 Hugh Mills, Ph.D., *Chairman*
Alfred Paul Koch, M.S.
Carl Leland Moore, M.A.
Wendell Piggott Trumbull, Ph.D.

Associate Professors

Francis Mario Brady, Jr., M.B.A.
Feng-Shyang Luh, Ph.D.

Lecturer

Robert A. Pfenning, M.B.A.

Major in Business and Economics College

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

Acctg 215	Intermediate Accounting (4)
	Accounting Electives (except Acctg 390) (11)

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	Business Data Processing (3)
Acctg 215	Intermediate Accounting (4)
Eco 129	Money and Banking (3)
Eco 206	Intermediate Economic Theory (3)
Law 1	Business Law (3)
Mgmt 302	Survey of Mgmt. Sci. Applications
	or
Mgt 321	Business and Organizational Behavior (3)

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

Note: Students interested in qualifying for the CPA 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. Business Data Processing (3)
An introduction to electronic data processing emphasizing general principles applicable to business data. The course includes (1) familiarization with a basic computer language, (2) uses of computers in processing information for the needs of business enterprises, and (3) the elements of integrated systems of financial information for business purposes. Not open to students who have had a previous equivalent (normally 3 hr.) course in computers.

215. Intermediate Accounting (4)
Intensive study of theory, generally accepted accounting principles, and problems concerned with presenting fairly the operating results and financial position of business entities; preparation, analysis, and interpretation of financial statements. Prerequisite: Acctg. 52.

For Advanced Undergradutes and Graduates

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 system. The course will consider the tools and techniques used by someone performing the systems function. Prerequisite: Acctg. 52 or 108 and Acctg. 111.

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.

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. 215.

319. Development of Accounting Principles (3)
A critical and historical survey of the develoment of accounting principles and theory in the twentieth century. Prerequisite: Acctg. 215.

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. 215.

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 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.

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 two seminars, respectively, in literature and history organized around some single theme in their respective fields. 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 20, 21	American Literature (6)

Required Major Courses

Six credit hours to be chosen from each group.

Engl 321	20th Century American Literature (3)
Engl 341	Contemporary American Literature (3)
Engl 343	American Romanticism (3)
Engl 344	American Realism (3)

Hist 319	Colonial America (3)
Hist 320	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, 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., depending on options selected

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 205	Linear Methods
	or
	Engineering Science Electives (3)
	Distribution Electives (9)

Junior Year, First Semester (16 credit hours)

	Language (4)
Mech 1	Statics (3)
CE 13	Civil Engineering Concepts (3)
	Distribution Electives (6)

Junior Year, Second Semester (15 credit hours)

	Language (3)
Mech 11	Mechanics of Materials (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 I (3)
Mech 102	Dynamics (3)
	Engineering Science Elective (3)

Senior Year, Second Semester (18 credit hours)

CE 110	Civil Engineering Laboratory (3)
CE 170	Sanitary Engineering I (3)
CE 222	Hydraulics Engineering (3)
CE 160	Structural Design (3)
	Engineering Science Elective (3)
	Elective (3)

Summer

CE 100	Industrial Employment. Eight weeks of industrial employment should precede fifth year. Consult chairman of department.

Note: Engineering science electives 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 & 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 (16 credit hours)

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

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 Elective (3)
	Distribution Electives (6)

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 Elective (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 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 (16 credit hours)

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

Junior Year, Second Semester (15 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)

Senior Year, First Semester (15 credit hour)

ME 101	Mechanical Engineering Design I (3)
ME 105	Thermodynamics II (3)
Mech 102	Dynamics (3)
Mech 203	Advanced Strength of Materials (3)
	Distribution Elective (3)

Senior Year, Second Semester (17 credit hours)

ME 231	Fluid Mechanics
	or
CE 121	Mechanics of Fluids (3)
CE 123	Fluid Mechanics Laboratory (1)
ME 242	Mechanical Vibrations (3)
	Distribution Electives (9)

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

Saul Benjamin Barber, Ph.D. *Chairman*
Thomas C. Cheng, Ph.D., *Director, Institute for Pathobiology*
Sidney Samuel Herman, Ph.D.
Richard Griffith Malsberger, Ph.D.
Basil Waldo Parker, Ph.D.

Associate Professors

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

Assistant Professor

Steven S. Krawiec, Ph.D.

Adjunct Professors

Edward John Benz, M.D.
Eugene M. Landis, M.D., 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 Preliminary Courses

Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Laboratory (1)
Biol 28	Genetics (3)

Required Major Courses

Biol 272	Senior Seminar (3)
	and a selection of 18 credits from the following:
Biol 34	Comparative Vertebrate Anatomy (4)
Biol 35	Microbiology (3)
Biol 221	Undergraduate Research (3)
Biol 261	Special Topics (1-3)
Biol 262	Special Topics (1-3)
Biol 303	Advanced Invertebrate Zoology (3)
Biol 306	Ecology (3)
Biol 309	Aquatic Biology (3)
Biol 313	General Histology (3)
Biol 314	Vertebrate Embryology (3)
Biol 317	Evolution (3)
Biol 320	Physiology (3)
Biol 333	Symbiosis (3)
Biol 334	Growth and Development in Plants (3)
Biol 336	Evolution of Land Plants (3)
Biol 353	Virology (3)
Biol 361	Sanitary Microbiology (3)
Biol 371	Elements of Biochemistry (3)
Biol 372	Advanced Biochemistry (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 90	Physical Chemistry (3)
Phys 16, 17	General Physics and Physics Laboratory (5)

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 90	Physical Chemistry (3)
Biol	Electives (3, 6, or 9)

Senior Year

Biol 272	Senior Seminar (3)
Biol	Electives (3, 6, or 9)

The Bachelor of Science Major

Required Preliminary Courses

Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Lab (1)
Biol 28	Genetics (3)

Required Major Course

Biol 272	Senior Seminar (3)
	and a selection of 24 credits from B.A. list above

Additional Required Courses

Math 21, 22, 23	Analytic Geometry and Calculus (12)
Math 41, 42, 43, 44	BMSS Calculus, Probability and Linear Algebra (12)
Chem 21	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Lab (1)
Chem 51	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)
	or 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
Geol 1	Principles of Geology (3)
Psych	Elective
	or
Phil	Elective (3)
Biol	Electives (6-12)

Senior Year

Biol 272	Senior Seminar (3)
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 or 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)
A study of 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. Prerequisite: One semester of biology

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)
A basic course for students majoring in biology. A study of the physiology, biochemistry, and morphology, including staining methods, of representative heterotrophic microorganisms. Recitations, lectures, and laboratory work. 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. Primarily 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.

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.

272. Senior Seminar (3)
Seminar, for biology majors only, on recent advances in biology. Introduction to research literature on selected topics. One 3-hour seminar per week.

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 semester of biology, one with laboratory.

309. Aquatic Biology
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: Bio. 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. Physiology (3)
Lectures and laboratory work covering the principles underlying the operation of life processes. The subject matter is not limited to any one group of organisms, but is derived from living things in general. Prerequisite: Two semesters of biology, one with laboratory: Chem. 52, or consent of the chairman of the department. Two lectures and one laboratory period per week.

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.

334. Growth and Development in Plants (3)
A comparative study of life cycles and embryo growth and 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. Prerequisites: Two semesters of biology and laboratory. Two lectures, one laboratory.

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.

353. Virology (3)
A lecture course on Rickettsiales, Virales, and bacterial viruses including taxonomy, physical and chemical properties, immunological characteristics, and evolution. Prerequisite: A course in microbiology or bacteriology.

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, one semester 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: Bio. 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 relations to cellular function ahd 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.

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.

432. Laboratory Methods in Virology (3)
Basic methods used in the isolation, identification, and handling of viruses. Practical exercises in the preservation of viruses, chick embryo techniques, tissue culture, staining methods, immunological techniques, and microscopy are included. Prerequisite: Biol. 353.

462. Advanced Microbiology (3)
A detailed consideration of algae, fungi, protozoa, and microorganisms other than the Eubacteriales of concern to the microbiologist or sanitarian. Two lectures and one laboratory period or field trip per week. Offered as required.

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

Associate Professors

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

Assistant Professors

Marvin Charles, Ph.D.
Leslie H. Sperling, Ph.D.

Lecturers

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

Research Associate

Juraj Gebauer, 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 page 44)

Sophomore Year, First Semester (16 credit hours)

Math 23	Analytic 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 90
Chem 90	Elective (3)
ChE 52	Fundamentals of Transport Phenomena (4)
ChE 52	Fundamentals of Transport Phenomena (4)
	Social Science Elective (3)

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	Modelling, 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 27 hours of electives must be taken from the following distribution:

Basic sciences (chemistry, physics, mathematics) 6 hours.
Engineering Sciences (including Mech. 1 or Mech. 103) 12 hours.
Free electives 9 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.

51. Chemical Engineering Computation (3)
Basic technical principles and laws of conservation as applied to chemical processing operations. Mathematical description of steady state and time variant systems. Digital and analog computation as applicable in these areas. One lecture, two recitations, and one calculation session per week.

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.

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.

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, 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.

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. Lectures and laboratory. 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. Characterisitcs 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: 1 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 two 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 are now forty-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 Inst. of Tech., Newark College of Engineering, U.C.L.A., Case, Penn State, Virginia, Maryland, N.Y.U. and Tufts. Last year the department awarded seventeen M.S. degrees, and three 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:
Reaction rates in shock wave fronts
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
Effect of long control lines on response of pneumatic control systems
Frequency response of process systems
Digital simulation of chemical process systems
Optimization of absorber operation
Feed-forward control of distillation columns

Polymer Characteristics:
Polymer crystallization mechanism
Compressibility of polymer melts
Characteristics of heterogeneous polymer systems
Diffusion in swollen polymers
Interfacial polymerization mechanisms

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 and Research, Air and Water Pollution with the Center for Marine and Environmental Sciences. 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 installation 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 extracive 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 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 1 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.

462. Mathematical Methods in Chemical Engineering II (3)
A continuation of Ch.E. 461 with emphasis on applications involving numerical methods.

470. Cryogenic Engineering (3)
Liquefication 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.
Edward Delbert Amstutz, Ph.D., *Distinguished Professor*
Charles Stephen Kraihanzel, Ph.D.
Henry Leidheiser, Jr., Ph.D., *Director, Center for Surface and Coatings Research*
John Alexander Manson, Ph.D.
Joseph Robert Merkel, Ph.D.
William Edward Ohnesorge, Ph.D.
Robert Stacy Sprague, 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.
James Edward Sturm, Ph.D.
John W. Vanderhoff, Ph.D., *Associate Director, Center for Surface and Coatings Research*

Assistant Professors

Matthew Harold Hulbert, Ph.D.
Thomas Russell Ortolano, Ph.D.
Gary W. Simmons, Ph.D., *Assistant to the Director, Center for Surface and Coatings Research*
Daniel Zeroka, Ph.D.

The Bachelor of Arts Major

Students who major in chemistry in the College of Arts and Science become eligible for the B.A. degree in chemistry. The following curriculum should be compared with that required for the B.S. in chemistry, for these differ in two respects. The B.A. curriculum requires fewer credits for graduation (120 vs. 122 hours) but has the same required courses in mathematics, physics, and chemistry. The B.A. program requires eighteen hours of credit in any one foreign language, while the B.S. requirements are five hours of German or Russian. German is strongly recommended for the majority of Lehigh chemistry students who go on to graduate school, where inadequacy in this language is a serious handicap.

Premedical students should note that the chemistry curricula have sufficient latitude to permit a very strong preparation for medical school.

Both curricula permit graduates to embark immediately upon graduate school work.

Required Preliminary Courses

Freshman Year

Chem 21, 22	Introductory Chemical Principles (5)
Math 21, 22	Analytical Geometry and Calculus I and II (8)
Phys 10, 11	Introductory Physics (5)

Required Major Courses

Sophomore Year

Math 23	Analytical Geometry and Calculus III (4)
Phys 21, 22	Introductory Physics (5)
Chem 51, 52	Organic Chemistry (6)
Chem 53, 54	Organic Chemistry Lab (3)
Chem 90	Physical Chemistry (3)

Junior Year

Chem 191	Physical Chemistry (3)
Chem 192	Physical Chemistry Lab (1)
Chem 234	Analytical Chemistry Lab (1)
Chem 280	Advanced Chemical Experimentation (3)
Chem 332	Analytical Chemistry (3)
Chem 302	Principles of Inorganic Chemistry (3)
Chem 308	Coordination Chemistry (3)
Chem 358	Advanced Organic Chemistry (3)

Senior Year

Chem 381	Radiation and Structure (3)
Chem 382	Structure, Electrochem & Kinetics (3)
Chem	Electives

Note: 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 350	Special Topics (3)
Chem 352	Organic Chemistry, 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 397	Colloid and Surface Chemistry (3)

The Bachelor of Science Major

Chemists constitute nearly one-half of all professional research personnel in industry as shown by a report of the Nation Resources Planning Board. The American Chemical Society, which requires professional training and experience for eligibility, has a present membership of over 120,000. The consistently rapid increase in the membership of this society in recent years may be taken as an index of the expanding opportunities in the chemical profession.

The curriculum in chemistry provides a thorough grounding in the fundamentals of this science, with the requisite collateral training in physics and mathematics. In addition to the liberal allotment of time of courses in English, German, economics, history and other non-professional studies, provision is made for twelve semester hours (ordinarily four courses) of professional electives in a minor field of concentration.

Since the freshman year of this curriculum is identical with that of chemical engineering, and the sophomore years in the two curricula are nearly the same, it is possible, by a slight rearrangement, for the student to transfer from one curriculum to the other before the beginning of the junior year without a considerable sacrifice of credits. In a transfer from chemical engineering to chemistry, the chemical engineering courses may be utilized as electives.

A special program leading to a B.S. in Chemistry and an M.S. in Materials is available for interested students. See Five-Year Programs.

Recommended Sequence of Courses

Freshman Year (See page 44)

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)
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)
	Elective (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	Electrochem 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 are to be chosen from the B.A. list above.

Undergraduate Courses

3. Chemical Principles II (3)
Topics include work in chemical equilibrium, and introductions to thermodynamics, kinetics, and electrochemistry. Selected descriptive chemistry of certain metallic and non-metallic elements. Prerequisite: Chemistry 1. Two lectures, one recitation.

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 examinations. Three lectures.

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 are discussed. Fundamental techniques are presented in the laboratory or by demonstration. 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, both aliphatic and aromatic. Prerequisites: Chem. 51 and Chem. 52 concurrently.

90. Physical Chemistry (3)
An introduction to physical chemistry aimed at a quantitative perspective on the behavior of matter. 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 gas kinetics, 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)
A continuation of Chem. 90. Emphasis on microscopic description of matter: nuclear and atomic structure, kinetic theory, 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.

196. Physical Chemistry (3)
For students not majoring in chemistry or chemical engineering. Kinetic theory and chemical kinetics; electrochemistry; topics in surface chemistry; atomic and molecular structure and bonding. 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 devoted to synthesis and analysis of compounds, physical chemical measurements and their interpretation, and application of computers to chemical problems. Prerequisite: Chem. 54, 192, 234.

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)
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 instrumentation. 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. Development of the total instrumental concept integrating all facets of the problem. 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. Electro-chemical 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.

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

352. Organic Chemistry, 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)
The practice of the common analytical procedures involving the quantitative estimation of carbon, hydrogen, halogen, nitrogen and sulfur; the iodine number methods; the hydroxyl value; the acid value and the saponification number. 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 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 carbohydrated, lipids, proteins, and nucleid acids; Photosynthesis, electron transport mechanism, coupled reactions, phosphorylations, and the synthesis of biological macromolecules. Prerequisite: Chem. 371.

375. Research Chemistry Laboratory (3) (Optional)
Advanced study or an investigation involving intensive work 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)
A study of the method and theory of the development of chemical information from radiation-matter interactions; macroscopic optics, scattering phenomena, quantal phenomena. Applications to problems of analytical, inorganic, organic and physical chemical interest. Three one-hour lectures and (optional) one three-hour laboratory. Prerequisites: Chem. 191 and 332.

382. Structure, Electrochemistry and Kinetics (3-4)
A unified study of matter in the process of change. Elements of irreversible thermodynamics; steady-state electro-chemistry; chemical kinetics, phenomenology and interpretation; non-steady-state electrochemistry; electrokinetic phenomena. Correlation with chemical structure. 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)
For course description, see Ch.E. 394.

397. Colloid and Surface Chemistry (3)
Introduction to concepts of colloid and surface chemistry. Classification of colloidal systems; determination of surface and interfacial tensions; spreading of films on liquids; types of emulsions; foams and aerosols; nature of the solid/gas and solid/liquid interface; causes of colloidal stability and determination of particle size; rheology of disperse systems. 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. 50 M.S. and Ph.D. candidates were enrolled in the department in the 1970-71 academic year.

A student may specialize in biochemistry, analytical, inorganic, organic, or physical 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 subscribes 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 commplete 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 at least one year of a foreign language, preferably 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 10 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; atomic absorption spectrometry of refractory forming metals; Hammett correlations with electrochemical reduction potentials; analysis in marine environment, luminescence of metal chelates; voltammetry in non-aqueous solvents; x-ray fluorescence methods of analysis.

Biochemistry: synthesis, 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; riboflavin—light reactions.

Inorganic chemistry: synthesis and characterization of amide complexes of transition metals; silicon organometallic compounds, and aryl and alkyl transition metal compounds; substitution and rearrangement reactions involving metal carbonyls; electronic structures of transition metal complexes as a function of ligand strength and of actual-vs-effective symmetry and coordination number; environmental effects on unsaturated complexes; vapor phase and single crystal electronic absorption spectroscopy of complexes.

Organic chemistry: synthesis of medicinal agents; correlation of molecular structure and pharmacological behavior; chemical models for biochemical reactions; sulfur bonding in novel heteroaromatic sulfur compounds; kinetics and mechanisms of reactions of organosulfur compounds; molecular orbital correlations of electronic spectra, redox potentials, and ionization potentials of heteroaromatic systems; equilibria and formation thermodynamics of heterocyclic charge transfer complexes, kinetics of chronic acid oxidations; photo-catalyzed reductions, oxidations, and enolizations; synthesis of new heterocyclic systems.

Physical chemistry: vacuum ultraviolet photochemistry; radiation chemistry; flash photochemistry and kinetic spectroscopy; surface chemistry of pigments, metals, semiconductors, and plastics; 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. 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, phorphorescence spectrometer, light scattering photometer, differential refractometer, flash photolysis apparatus, densitometers, preparative and analytical gas chromatographs, ellipsometer, double-beam infrared and ultra-violet-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 repirometer, 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 62 in 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 reaction, 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.

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.

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.

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, equilibria and kinetics of point defects in ionic and semi-conducting crystals, surface states and surface fields in crystals. Prerequisite: Chem. 191 or equivalent.

445. Elements of Theoretical Chemistry (3)
An introduction to fundamental chemical physics. Quantum chemistry of simple systems; theories of chemical bonding; approximation methods. Molecular structure and spectroscopy. Principles of chemical thermodynamics including first, second and third law considerations; properties of state functions. Prerequisite: One year of physical chemistry.

446. Elements of Theoretical Chemistry (3)
Applications of chemical thermodynamics to gases, various types of equilibria, and chemical reactions with emphasis on real systems. Elementary statistical thermodynamics. Kinetic processes; rate laws and mechanisms; kinetic theory and transition state interpretational. Prerequisite: Chem. 445 or consent of chairman of department.

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.

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.

458. Topics in Organic Chemistry (3)
An intensive study of limited areas in organic chemistry.

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.

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.s,

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.

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.

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 Physical Chemistry Seminar (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.
Roger George Slutter, Ph.D.
Bung-Tseng Yen, Ph.D.

Assistant Professors

Terence John Hirst, Ph.D.
Robert Leroy Johnson, Ph.D.
Celal Nizamettin Kostem, Ph.D.

Visiting Assistant Professor

Osman Ahmed El-Ghamry, Ph.D.

Instructors

Joseph A. Corrado, M.S.
Sampath N. S. Iyengar, M.S.

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, geology, soil mechanics, fluid mechanics and hydraulics, structural theory and design, transportation engineering and sanitary 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 44)

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 (4)

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	Sanitary 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 (6)
	Elective (6-9)

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.

Undergraduate Courses

10. Problem Computation Laboratory (1)
Preparation of problems for computer programming with emphasis on problems in civil engineering; technique of programming for computers.

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.

12. Applied Engineering Graphics (2)
Drawings for civil engineering projects; graphical solutions and representation of data. Prerequisite: C.E. 11.

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.

112. Advanced Mechanics of Materials (3)
Further topics in column and beam theory, including unsymmetrical bending, combined stresses, conjugate beam methods; curved beams, impact loading, buckling. Prerequisite: Mech. 11.

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)
Origin, composition and structure of soils. Fundamental physical, chemical and mechanical properties affecting the engineering behavior of soils. Phase relationships; unit weights; identification; classification; permeability; effective stress and pore water pressure; compaction, compression and consolidation; stress-strain behavior and shear strength; site exploration and measurement of engineering properties. Application of theories and principles in engineering practice. Prerequisite: Mech. 11 or consent of department chairman.

151. Structural Theory (3)
Introductory course in the theory of structural steel design, including bolted, riveted and welded connections, pins, tension members, columns, and beams. Prerequisite: C.E. 150.

153. Reinforced Concrete Theory (3)
Analysis and design of reinforced concrete structural elements including beams, slabs and compression members by both the ultimate strength and working-stress methods. Analysis and design of footings and retaining walls. Introduction to prestressed concrete. Prerequisite: C.E. 154.

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. 153 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. Sanitary 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. 239.

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 shallow and deep foundations. Lateral loads on retaining walls and bulkheads. Buried structures. Prerequisite: C.E. 143 or equivalent.

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.

271. Sanitary 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.

316. Civil Engineering Planning (3)
Planning of civil engineering projects; selection of site; situation survey and data analysis; consideration of utilities; transportation; parking; architectural and structural features of structures; subsurface exploration; air and water pollution control; landscaping; economic studies; estimates of costs; general plans and reports. Prerequisite: Consent of chairman of department.

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.

327. Hydraulics (3)
Hydraulic models, flow measuring devices, unsteady pipe flow, design of open channels for gradually and rapidly varied flow, sediment transportation. Centrifugal pumps and turbines. Emphasis on design and application of empirical data. Prerequisite: C.E. 121 or consent of department chairman. Offered on sufficient demand only.

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)
Background information and identification of the present and probably future ocean industries, emphasizing contributions from the principal engineering disciplines to man's exploration and exploitation of the oceans. 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.

342. Soil Stabilization (3)
The mechanisms of soil stabilization: compaction, use of additives (aggregates, cement, asphalt, chemicals). 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. 239 or equivalent.

351. Structural Design: Timber (3)
Analysis and design of timber columns, beams, tension members, trusses, connections, mechanical fasteners; study of allowable stresses, fire resistance, and preservation of timber structures; project and timber tests with reports. Prerequisite: A course in structural design and theory.

352. Structural Dynamics (3)
Analysis of linear structural systems to time dependent loads. Free and forced vibration. Classical and numerical methods of solution. Lumper-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. 154 or equivalent.

364. Structural Concrete Members (3)
Analysis and design of structural concrete members under various loading conditions. Transverse, torsional and repeated loading. Serviceability criteria. Elastic methods for reinforced concrete slabs. Introduction to prestressed concrete. Prerequisite: C.E. 153 or equivalent.

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.

381. Special Topics (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 sanitary engineering, leading to the M.S. and Ph.D. degrees; 38 Ph.D. and 37 M.S. candidates were enrolled in the department in the 1970-71 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 his 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 science 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, sanitary 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 and Environmental Sciences 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. Interactive, 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; PERT and CPM. 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 Topic 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. 239 or equivalent.

439. Ocean Engineering Research (1-6)
Individual research problems with reports. May be repeated for credit.

442. Experimental Soil Mechanics (3)
Group discussion and 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; measurement of pore-water pressures; model design and analysis field measurement of in situ soil properties; laboratory and field instrumentation. Prerequisite: C.E. 239 or equivalent.

443. Advanced Soil Engineering 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; theory of compaction; frost action; application of hydro mechanics to soil engineering problems. Prerequisite: C.E. 239 or equivalent.

444. Advanced Soil Engineering II (3)
Fundamental and advanced theories of soil mechanics applicable to earth structures and foundation design; stresses in wedges and in layered systems for ideal elastic, plastic and viscoelastic soils, theory of consolidation, vibrations 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 rigid structures. Stress distribution due to loads on shallow and deep foundations; soil compression and rupture theories; analysis and limitations of

settlement; structural design of foundations; construction problems; and site investigations. Prerequisite: Consent of chairman of department.

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)
Deflections due to various causes. Force and deformation methods of analysis of structures using matrix algebra. Consideration of influence of settlement, temperature and tolerance on member forces. Prerequisite: C.E. 154 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. 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-bulking 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. Analysis and design of statically indeterminate prestressed concrete structures. Loss of prestress. Partial prestress. Limit design, including yield line theory. Structural behavior of reinforced concrete members. Prerequisite: C.E. 364, or equivalent.

466. Concrete Shell Structures (3)
Analysis and design of varions types of concrete shell structures. Folded plates, barrel shells and shells of double curvature. Application of prestressing. Prerequisite: C.E. 403 and C.E. 364 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; interactior 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. 170.

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. 170.

475. Advanced Topics in Water Resources (1-3)
Advanced study of selected topics in areas such as: physical-chemical methods in water treatment; multiple use of water resources; and others. Selection of topics will depend on particular qualifications of the staff, as well as interest of the students. Prerequisite: Consent of department chairman. May be repeated for credit.

479. Sanitary Engineering Research (1-6)
Individual research problems in sanitary engineering with summary report. May be repeated for credit.

481. Special Problems (1-6)
An intensive study, with report, of some special field of Civil Engineering which is not covered in the other courses. A design project or an interdisciplinary study of some problem related to Civil Engineering may also be included. May be repeated for credit.

483. Graduate Seminar (1-3)
Study of current topics in the field of civil engineering.

491. Thesis (1-6)

Classics

Professors

Joseph Abele Maurer, Ph.D. *Chairman*
Douglas David Feaver, Ph.D.

Associate Professor

Edna Sophia DeAngeli, Ph.D.

Majors in Classics seek, through insight into the culture of ancient Greece and Rome, to gain an appreciation of Greco-Roman achievements in art, literature, philosophy, and science, and to formulate an evaluation of the importance of these for modern culture. Readings in the original languages of masterpieces, chosen both for their usefulness in developing skill in the languages and for their intrinsic worth and abiding importance, aim at developing an accumulative growth in the mastery of the languages and in the ability to interpret, criticize, and evaluate the achievements of classical civilization.

The basic work is supplemented by studies in the history, archaeology, art, philosophy, and literary history of Greece and Rome, and by an introduction to the basic tools and disciplines of scholarly research in this area. Students are encouraged to undertake research in fields of their own interest.

Classics as a major has stood the test of time, offering a general cultural background for careers in widely diverse fields in the professions, business, and public service. It has particular relevance as a preparation for careers in teaching, law, writing, archaeology, and the church.

Lehigh University is a cooperating institution of The American School of Classical Studies at Athens. Graduates of Lehigh University receive free tuition in the school.

Major in Greek

Required Preliminary Courses

Gk 1, 2	Elementary Greek (6)
Gk 3, 4	Intermediate Greek (6)

Required Major Courses

Gk 111, 112	Greek Drama (6)
Gk 113	Greek Historians (3)
Gk 203	Greek Epic (3)
Gk 271	Readings (3)
Gk 316	Plato (3)
Gk 21	Ancient History (3)
Gk 50	Greek Literature in English Translation (3)

Gk 202 Greek Archaeology (3)

Majors in Greek 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

Astr 1 Descriptive Astronomy (3)
FA 5 Fundamentals of Art (3)
FA 3 Pre-Renaissance Architecture (3)
Phil 231 Ancient Philosophy (3)
SR 31 Cultural 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: *Eurthyphro, 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)
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

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.

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, Terramar, 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 Catallus 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*
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

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

Assistant Professors

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

Adjunct Professors

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

Instructor

Keith H. Corkum, M.S.

Major in Arts and Science College

Required Preliminary Courses for B.A.

Freshman Year

Eco 1	Economics (4)
Math 41	BMSS Calculus I (3)
Math 42	BMSS Probability (3)
Math 43	BMSS Linear Algebra (3)

Required Major Courses

Sophomore Year

Eco 206	Intermediate Economic Theory (3)
Eco 316	Intermediate Macro-Theory (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)

A senior comprehensive examination is required.

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, foreign exchange, 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 a one-year course in the principles of economics.

206. Intermediate Micro-Economic Theory (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.

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 and present lines of research. Exposition, comparison, and appraisal of the method and theories of selected major economists from 1900 to present concerning the economic order, the corporation, production, industrial structure, market conduct, money, the operation of the aggregate economic system, business cycles, social welfare, and the role of the state.

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. Prerequisite: Eco. 206 or consent of the instructor.

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. Prerequisite: Eco. 1 and consent of instructor.

316. Intermediate Macro-economic Theory (3)
Introduction to the theory of income, employment, and growth. Provides tools of analysis necessary for dealing with aggregate economic problems.

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: A course in money and banking.

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: Economics 306 or consent of the 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 commerical 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)
Applied 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 316.

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: Fin. 351.

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 316.

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. Micro-Economics (3)
A survey of methods of decision making at the micro-economic level utilizing concepts developed in price theory and econometrics. Prerequisite: Eco. 206 or equivalent.

435. Micro-Economic Analysis (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. Macro-Economics (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: Math. 205 or the consent of the 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 these 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*
Andrew J. Edmiston, Ph.D.
Norman H. Sam, Ed.D.
Merle W. Tate, Ed.D.

Associate Professors

Alfred J. Castaldi, Ed.D.
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.
John A. Mierzwa, Ed.D.
Paul Van Reed Miller, Ph.D.
Estoy Reddin, Ed.D.
Elvin G. Warfel, Ed.D.

Assistant Professors

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.
Alice D. Rinehart, Ed.D.
William B. Stafford, Ed.D.
LeRoy J. Tuscher, Ph.D.

Adjunct Professors

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

Instructors

Raymond Bell, M.Ed.
Frederic L. Evans, M.Ed.
Audrey L. Gilmartin, B.S.
Gretchen A. Henninger, M.Ed.
Michael R. Krasley, B.S.
Ella Jane Kunkle, B.A.
Beverly G. Miller, B.A.
Judith L. Neale, B.S.
William L. Nelson, M.Ed.
Ruth B. Parr, M.Ed.

Carol Strelecki, M.S.
Harry A. Tachovsky, B.S.
George VanDoren, M.A.

Lecturers

Roy C. Claypool, M.Ed.
Jacob E. Dailey, Ed.D.
George Douris, M.F.A.
James J. Fadule, Ed.D.
Edwin B. Keim, Ed.D.
William E. Keim, Ed.D.
Donald K. Kirts, Ed.D.
William W. Oswalt, Ed.D.
Henry W. Ray, Ed.D.
Richard C. Richardson, Ph.D.
Sylvia Rutkoff, M.A.
Stephen A. Schafer, Ed.D.
Theodore M. Stephens, Jr., M.S.
Dale Tyson, Ed.D.

For Advanced Undergraduates and Graduates

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.

320. Counseling the Disadvantaged Individual (3)
Study of theories and techniques of counseling with disadvantaged persons. Enrollment limited to Employment Service Counselors.

330. Study of the Individual (3)
Examination of individual growth and development, especially the patterns found in different sub-cultures. Enrollment limited to Employment Service Counselors.

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.

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.

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 sub-cultural 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)
The theory of individual and social adjustments and the individual and cultural factors in learning of motives and adjustments with particular reference to the educative processes and the work of educational institutions. Relationships to the typical varieties of adjustive behavior and determinents of personality are shown. Mental life, conduct, personal, and social adjustment are analyzed with regard to changing conceptions of self and interplay of emotion and intellect. Prerequisite: consent of instructor.

412. Individual Assessment and Interviewing (3)
A study of the appraisal process and the data used to understand and predict educational, vocational, and social behavior. Surveys of advanced methods and instruments in appraisal including comparison of diagnostic approaches, interpretation of research, preparation of written reports, and application in practice are included. Prerequisite: Consent of instructor.

413. Theories of Psychological Counseling (3)
A historical analysis and synthesis of concepts drawn from Jung, Rank, Freud, Adler, and neo-analysts with particular reference to the educative process and the work of educational institution. The research and current trends in counseling on educational, social, and vocational problems are studied. Precepts and practices in mental health screening are examined. Prerequisite: Consent of instructor.

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)
Methods of instruction and provision of materials for children who differ markedly from the normal, i.e., gifted, subnormal and maladjusted; the problems of the teacher in a system that makes little provision for the exceptional child. Actual case studies of pupils are required.

423. Diagnostic and Remedial Teaching (3)
The role of the classroom teacher as a diagnostician of correc tive 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 semester. 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)
A study of various types of specific learning disabilities and their effects on development and learning; a survey of various theoretical approaches; diagnostic and remedial procedures.

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 the frequency distribution. Types of distributions. Simple correlation and regression. Score transformations. Statistical inference: tests of hypotheses and estimation of parameters. Uses of the normal, *t*, and chi-square sampling distributions.

456. Statistics II (3)
Review of descriptive statistics. Moments of the frequency distribution. Errors of inference and their control. Power of a statistical test. Extended applications of the binominal, normal, *t*, and chi-square sampling distributions. The F distribution. Simple analysis of variance and covariance. Special methods of correlation. Multiple linear correlation and regression through the four-variable case. Prerequisite: Educ. 455.

457. Statistics III (3)
Selected topics including complex designs in analysis of variance and covariance, multiple correlation and regression factor analysis, and nonparametric methods. Emphasis on experimental design. Prerequisite: Educ. 456 and consent of instructor.

458. Statistics IV (3)
Writing and testing computer programs; use and adaptations of packaged programs; special applications in educational research, administration, and instruction. Prerequisite: Educ. 456.

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 of 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 hours course, may be repeated for a maximum of six credits.

471. Evaluation in Education (3)
Primarily for classroom 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)

476. Seminar in School Finance (3)

477. Seminar in School-Community Relations (3)

478. Seminar in School Personnel Problems (3)

479. Seminar in School Law (3)

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

482. Philosophy and Principles of Guidance (3)
Introduction to the guidance of children and youth in elementary and secondary school and to guidance of adults in school, business and industry. Theoretical foundations, principles and ethics of guidance are considered together with implications for school and extra-school experience. Guidance functions such as identification, appraisal, placement, orientation, motivation, support, curriculum design, and resource development are surveyed. Organizations of school personnel programs are analyzed.

483. Counseling (3)
An intensive examination of theories and techniques of counseling. Students will conduct counseling. Students will conduct counseling interviews. Prerequisite: Educ. 482.

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, superintendent 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, M.S., *Distinguished Professor*
Walter Emil Dahlke, Ph.D.
Nikolai Eberhardt, Ph.D.
Arthur Irving Larky, Ph.D.

Associate Professors

William Avon Barrett, Ph.D.
Carl Sanford Holzinger, Ph.D.
Daniel Leenov, Ph.D.
Leslie Guy McCracken, Jr., Ph.D.
John George Ondria, Ph.D.

Assistant Professors

Bruce Dale Fritchman, Ph.D.
Frank H. Hielscher, 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.
Grayson E. McNair, B.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, system engineering, and 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 in 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 contain laboratory work.

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.

The electrical engineering department encourages all undergraduates to seek industrial experience while undertaking their course of study. This can be accomplished through summer employment or, in a more substantial manner, through the cooperative programs. These provide for several semesters of assignments at forward-looking companies where the student is offered participation in projects with high technological content. A professional internship of this type will often add to the competence of the individual and will accelerate his growth by giving him the opportunity to relate his studies to actual engineering problems. Application for entry into the cooperative programs is open to all students in good standing, but selection of individuals is made by the participating companies.

Recommended Sequence of Courses

Freshman Year (See page 44)

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 (4)
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 (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)
	GS Requirement (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 (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 load required to meet the graduation requirement; the higher 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.

Undergraduate Courses

11. Introduction to Computer Engineering (3)
Introduction to computer-system organization, system software, data structures, and the basic concepts behind user-oriented languages. Machine structure; memory organization and its allocation for data aggregates; number representation and the mechanization of arithmetic. Fundamental types of programming statements and program structure. Functions, subprograms, and procedures. Iteration and recursion. Assembly language and assemblers. 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 included: 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 not in a cooperative program are expected to spend at least eight weeks getting experience in some industrial organization 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. 4, or Phys. 21.

104. Linear Systems and Signals (4)
Fourier series, Fourier integral, Laplace transforms and their application to linear systems. Introductory treatment of signal theory; correlation functions and spectra. Modulation and detection. Prerequisite: E.E. 16 or E.E 20.

105. Electronic Circuits (4)
Introduction to methods for analyzing and designing circuits containing modern 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. 16 or 20.

106. Electromechanics and Machines (3)
Principles of electromagnetism and their application in electromechanical devices. Analysis and design of transformers, saturable control elements, solenoidal actuators, multi-phase power systems, and AC and DC rotating machinery. Prerequisite: E.E. 16 or 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 upon both 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. Weekly lecture plus one three-hour laboratory session.

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)
Three choices open, each occupying two-three-hour sessions per week.

Project laboratory. Similar to E.E. 151.

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 concurrently.

Semiconductor laboratory. Measurements of basic physical parameters of semiconductors. Hall effect. Fabrication of p-n junctions by alloy and diffusion processes. Introduction to planar technology: photoresist and oxide masking processes.

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. 4.

161. Electrical Problems (1)
A weekly recitation period intended to supplement the material in E.E. 160 lectures and 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)
Switching algebra. Function simplification and its application to two-level 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. Matrix representation of networks. 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.

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.

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. No specialized background assumed. Text material taken primarily from the current literature, with emphasis on computer applications. Prerequisite: Consent of instructor.

342. Communication Theory (3)
Introduction to statistical communication theory with primary emphasis on discrete systems. Topics covered include stochastic processes; signal design; time, bandwidth and dimensionality relationships; optimum receiver design for dispersive and non-dispersive channels; performance bounds and channel capacity theorems. 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.

361. Physics of Materials (3)
Introduction to 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, Math. 221 or 205, and Phys. 31.

373. (I.S. 373, Math. 373) Mathematical Methods in the Information Sciences
See I.S. 373 for description.

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 include low-, medium-, high-, and microwave-frequency components. Special research facilities are available for the study of semiconductor networks, noise in electron devices, and digital functions. A laboratory with ultra-high vacuum equipment is available for the study of semiconductor surfaces and the preparation of special devices.

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.

406. Physics of Magnetism (3)
Origins of magnetism. Depolarizing tensors, gyromagnetic effects, spin-orbit coupling. Lande g factor, magnetostatic, magnetoelastic, magnetocrystalline, and exchange energies; static and dynamic magnetization processes, resonance studies. Wave propagation in ferrites.

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-Petterson 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-curcuit 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 appropriate for exploiting electrical devices and networks more powerful than conventional gates. Major topics included: logical completeness, threshold logic, multivalued logic, synthesis with assumed network forms, error diagnosis and fault masking in switching circuits.

432. Finite State Machines (3)
Emphasis on behavioral aspects of digital machine models. Major topics included: description of sequential behavior, Gedanken experiments, error control, information loss-lessness, iterative systems. Synthese of sequential machines canonic forms.

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 conventional codes for random or burst-error correction (or both); decoding algorithms and their circuit implementations.

443. Network Theory (3)
Properties of driving-point and transfer functions; synthesis; realizability and positive-real functions. Introduction to active network synthesis.

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 and Technology of Semiconductor Devices (3)
Vapor phase growth, thermal oxidation, solid-state diffusion. Bulk and surface recombination. Applications to p-n junctions, Schottky barrier diodes, and metal-insulator-semiconductor structures. Prerequisite: E.E. 308 or its equivalent.

452. Solid State Device Theory I (3)
Transport theory, conductivity, electron phonon scattering, hot electrons, avalanche breakdown. Applications to Gunn and IMPATT avalanche 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 transistor. 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 and flicker noise. Noisy networks: representation and optimization. Electron tubes and transistors.

462. Noise in Microwave Devices and Networks (3)
Devices and circuits treated include: masers; parametric, point contact and tunnel diodes; negative resistance amplifiers; mixers; local oscillators.

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

Associate Professors

Cloyd Criswell, M.A.
Jack Angelo DeBellis, Ph.D.
John F. Vickrey, Ph.D.

Assistant Professors

Peter G. Beidler, Ph.D.
Addison C. Bross, Ph.D.
Edward J. Gallagher, Ph.D.
Robert Richard Harson, Ph.D.
Eustace Anthony James, Ph.D.
Albert J. Solomon, Ph.D.

Instructors

George Buchanan MacDonald, M.A.
Peter Tinker, M.A.

Lecturer

John Ross Baker, M.A.

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 and 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, 2	Composition and Literature (6)
	or
Engl 11, 12	Types of World 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 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, philsophy, 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.

Journalism

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, economics, government, history, international relations, languages, literature, philosophy, science, and sociology.

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 in the journalism major. A minimum of four semesters is required.

Recommended Electives

Majors in journalism are advised to enroll in certain courses in economics, English, government, history, international relations, philosophy, and sociology. Electives should be chosen in consultation with the major advisor.

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 (a) the regular freshman courses, Engl. 1 and 2, (b) the Engl. 11 and 12 program as outlined below, or (c) the Advanced Placement Tests administered by the College Entrance Examination Board. First semester freshmen are divided, on the basis of preliminary tests, into two groups: (1) those whose preparation appears to have been adequate but who do not give evidence of outstanding ability, and (2) those who give evidence of outstanding ability. Students in Group 1 are required to take Engl. 1 and 2; those in Group 2 are given the option of taking either Engl. 11 or 12 (an advanced course in World Literature) or Engl. 1 or 2.

So that superior students may be enabled to satisfy their requirements more rapidly and thus accelerate their progress, those students of Group 2 who elect to take Engl. 11 and 12 will be given credit for Engl. 1 and 2 upon receiving a grade of B or better in Engl. 11 and 12. Thus the superior student can receive twelve credit hours for taking six credit hours of Engl. 11 and 12. If the student does not receive a grade of B or better in Engl. 11 and 12 he will not receive credit for Engl. 1 and 2.

A student whose classwork shows that he has been placed in the wrong group may be transferred to a higher or lower group at any time during the year, if his instructor recommends and the chairman of the department approves the transfer.

1. Composition and Literature (3)
Practice in expository writing and the application of rhetorical principles; study of the essay and of verse.

2. Composition and Literature (3)
Continuation of Engl. 1. Further practice in expository writing in conjunction with the study of drama, the novel, and the short story. Prerequisite: Engl. 1

11. Types of World Literature (3)
A course in composition and literature for superior students who do not need or who have had the basic training of Engl. 1 and 2. In addition to wide and thoughtful reading in world masterpieces, the course requires correct and effective writing of critical essays, original sketches, and documented research papers. Not open to student who have taken Engl. 36.

12. Types of World Literature (3)
Continuation of Engl. 11. Not open to students who have taken Engl. 36. May be taken independently of Engl. 11.

English Literature and Advanced Composition

Students wishing to major in English literature should take as preliminary work Engl. 8 and 9, or such equivalent courses as may be recommended by the chairman of the department. They should then elect a total of ten advanced English courses in the junior and senior years. Students working for honors take a course in which they prepare a thesis as part of the honors requirement

4. A Study of the Drama (3)
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 or 12.

5. A Study of the Drama (3)
Continuation of Engl. 4. Prerequisite: Engl. 2 or 12.

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 or 12.

8. English Literature (3)
A survey of English literature from *Beowulf* through the Pre-Romantics, with selected readings. Prerequisite: Engl. 2 or 12.

9. English Literature (3)
A survey of English literature from Wordsworth to Housman. Prerequisite: Engl. 2 or 12.

18. The Novel (3)
A study of a selection of novels as noteworthy works of literature. Prerequisite: Engl. 2 or 12.

19. The Novel (3)
Chronological continuation of Engl. 18. Prerequisite: Engl. 2 or 12.

20. American Literature, 1607-1855 (3)
A survey of the major writers from the settlement of America to the Civil War. Lectures and class discussions. Prerequisite: Engl. 2 or 12.

21. Modern American Literature (3)
A study of the development of American literature from Whitman to the present day. Lectures and class discussions. Prerequisite: Engl. 2 or 12.

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 or 12.

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. Not open to students who have taken Engl. 11 or 12. Prerequisite: Engl. 2.

142. Technical Writing (3)
Study and practice in forms and methods of technical exposition, description, definition, classification; the technical report, abstract. Prerequisite: Engl. 2 or 12.

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 1970-71, 27 Ph.D. and 135 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.

A candidate for the master's degree in English is 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.

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.

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.

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.

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

342. Contemporary European Literature (3)
American 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; the Black experience in America: 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 (Addison and Steele) and in the satire and comic moralism of Swift, Fielding, Johnson, and Goldsmith.

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 survey 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 Speech and Dramatics

Professor

H. Barrett Davis, B.L.I., *Chairman*

Associate Professor

Thoburn Vail Barker, M.A.

Instructor

John A. Schnaible, B.A.

Speech Clinic

For the purpose of diagnosis and treatment of speech defects. Individual instruction provided for students with minor distrubances 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.

11-13. Principles of Theatre Art (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.

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.

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.

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 the head of the division.

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.

61. Dramatics (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. One play is presented each semester.

62. Dramatics (3)
Continuation of Speech 61. Prerequisite: Speech 61.

For Advanced Undergraduates and Graduates

260. Speech for the Teacher (3)
An orientation course in the field of speech for those engaged in classroom teaching or in directing extra-curricular speech activities. Discussion as a teaching device; integration of speech with other subjects; recognition of common defects of speech; modern emphases in speech contests. Individual investigations, reports, and conferences. Summer session.

Division of Journalism

Professors

Joseph Brendan McFadden, M.A., *Chairman*
Robert Joseph Sullivan, M.A.

Journalism majors must successfully complete at least four semesters of Journ. 1-10, *Brown and White,* taking it during each semester of residence following the declaration of their major. They must also take Journ. 11, 12, 17, 113, 115, 120, 121, and 122.

1-10. Brown and White (1 or 2)
Enrollment constitutes membership on the staff of the semi-weekly paper. Students enrolling for their first semester register for Journ. 1; for their second semester, Journ. 2, etc. Prerequisite: Consent of 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: Engl. 2.

22. Creative Writing (3)
Continuation of Journ. 21. Prerequisite: Engl. 2.

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 responsiblities of the press.

122. Law of the Press II (3)
Law of and defenses in libel; privacy; contempt; copyright; obscenity.

Environmental Sciences & Resource Management

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)
	or
Engl 11	Types of World Literature (3)
Engl 2	Composition and Literature (3)
	or
Engl 12	Types of World 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 398	Special Problems in Environmental Science (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	Sanitary 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	Sanitary 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 90	Physical Chemistry (3)
Chem 191	Physical Chemistry (3)
Mech xx	(Statics and 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
	or
Engl 11	Types of World 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	Composition and Literature
	or
Engl 12	Types of World 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	Sanitary Engineering II (3)
	Electives 12

Senior Year, Second Semester (15 credit hours)

Geol 398	Special Problems in Environmental Science (3)
	Electives 12

Fine Arts

Professors

Richard James Redd, M.F.A., *Chairman*
Francis Joseph Quirk, Dipl.

Associate Professor

Carlos J. Alvare, M.C.P.

Assistant Professor

Leon N. Hicks, Jr., M.F.A.

Lehigh University has a cooperative agreement with Moravian College by which art students from either campus may register for courses at the other institution. All cross-listed courses are indicated below. Students registering for Moravian College courses must have the consent of the chairman of the Lehigh University Department of Fine Arts.

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.

The art history program gives the student a foundation in the evolution of European art from ancient to modern times and is designed for those who wish to pursue this area of the humanities as a professional art historian.

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 campuses.

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 51	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 40	Ceramics (Moravian) (3)
Art 113	Sculpture (Moravian) (3)
	One of the following:
Gk 202	Greek Archaeology (3)
Lat 203	Archaeology of Italy (3)
SR 31	Cultural Anthropology (3)
	Nine of the following, at least four at the 200-level for 27 credit hours:
FA 3	Pre-Renaissance Architecture (3)
FA 4	Architects and Architecture (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 219	19th Century Painting (3)
FA 220	20th Century Art (3)
FA 216	Art in the U.S. (3)
FA 271	Readings (3)
Art 222	Seminar in Contemporary Art (Moravian) (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. 150; Govt. 357; Geol. 211.

Undergraduate Courses

Art History and Appreciation

3. Pre-Renaissance Architecture (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. Architects and Architecture (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.

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.

216. Art in the U.S. (3)
A study of phases of American expression. Painting, sculpture, architecture in relation to cultural progress from Colonial to present time. The analogical and synthetic approaches to art as an index of changing environment. Museum Research. Reports.

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.

271. Readings (3)
Readings in the visual arts for students who wish to pursue special interest in art history, art criticism or aesthetics not covered by the regular course offerings. Prerequisite: Consent of chairman of the department.

Art and Architectural Studio

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)
An introductory course emphasizing instruction in drawing in various media, leading to woodcut and intaglio 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. May be repeated for credit.

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)
Guided independent practice in graphic techniques on a beginning level. Relief and intaglio printmaking. Prerequisite: F.A. 11. Studio.

40. Ceramics (3)
Elementary problems in the basic techniques of hand built and wheel thrown pottery. Moravian College campus.

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.

51. Urban Design (3)
The role which the design and planning professions play in influencing the form and function of the city. Analysis of the theoretical and actual roots of current concepts of planning and design, with special reference to the means and methods of programming, design, construction and evaluation of such urban scale projects as public housing, mass transit networks, cultural centers, satellite towns. Prerequisite: U.S. 21 or consent of chairman of department.

113. Sculpture (3)
Modeling, carving and construction in clay, plaster, wood, stone and metal. Emphasis on creative expression and experimentation. Prerequisite: One previous studio course in design or drawing. Moravian College campus.

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)
Continuing work in intaglio and relief printmaking offering deeper creative involvement and experimentation. Prerequisite: F.A. 37. Lehigh and Moravian College campuses.

140. Intermediate Ceramics (3)
Problems in wheel throwing construction and decoration. Emphasis on creative expression and experimentation. Prerequisite: Art 40. Moravian College campus.

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.

213. Sculpture II (3)
Individual problems in a variety of three dimensional media. May be repeated for credit. Prerequisite: Art 113. Moravian College campus.

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 relief printing. Emphasis on experimentation and mixed media. May be repeated for credit. Prerequisite: F.A. 137 or consent of chairman. Lehigh and Moravian College campuses.

240. Advanced Ceramics (3)
Individual problems in thrown and hand built pottery. May be repeated for credit. Prerequisite: Art 140. Moravian College campus.

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.

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.

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	Foreign Governments (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 required 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 other arts option.

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 designed for a student who wants to make an early start on a career in electronics and electronic device research and development. It differs from the four-year programs in electrical engineering or physics in that it provides additional opportunities for study of the fundamental principles of dialectic, magnetic and semiconductor materials along with a study of circuits in modern communications and control systems.

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 44.)

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 (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	Electrostatics (3)
EE 142	Junior Lab (2)
	Approved Elective (3)
	GS Requirement (3)

Summer

EE 100	Industrial Employment

Senior Year, First Semester (18 credit hours)

EE 11	Proseminar (1)
EE 151	Senior Lab I (2)
EE 245	Electromagnetic Theory (3)
Phys 213	Electromagnetism (3)
Phys 215	Particles & Fields I (3)
EE	Departmental Electives (3)
	GS Requirement (3)
	Elective (3)

Senior Year, Second Semester (17 credit hours)

Phys 216	Particles & Fields II (3)
EE	Departmental Electives (8)
	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 309	Theory of Probability (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 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 44.)

Sophomore Year (Same as Industrial Engineering)

Junior Year, First Semester (18 credit hours)

IE 101	Fundamentals of Manufacturing Engineering (3)
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, Mktg. 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	Marketing (3)

Senior Year, Second Semester (18 credit hours)

IE 154	Project (3)
IE	Electives (6)
	GS Requirement (3)
Engl	Elective (3)
Fin 225	Principles of Corporation 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 1	Business Law (3)
Eco 129	Money and Banking (3)
Psych 201	Industrial Psychology (3)

Fifth Year, Second Semester (12 credit hours)

Eco 206	Intermediate Micro-Economic Theory (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 339	Industrial Manpower Management (3)
Mgt S 321	Business and 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 masters degree in business administration within that period. In addition to one year of study 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. Fifteen to eighteen 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 and 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.A. 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 undergraduate students can provide for the required prerequisite courses in typical engineering B.S. degree programs; alternately, 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 a representative 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 Diagram & Transformation (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)
EE 304	Semiconductor Electronics (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 (3)
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	Transformation (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)
EE 404	Solid State Device Theory (3)
EE 406	The Physics of Magnetism (3)
Geol 336	Mineral Phase Relations (3)
Geol 433	Sulphide Phase Equilibria (3)
Geol 435	Advanced Mineraology (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)
Phys 471	Non-linear Continuum Mechanics (1-3)
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	Sintering and Related Phenomena (3)
Met 433	X-ray Metallography (3))
Met 437	Theory of Dislocations (3)
Met 443	Solid State Chemistry (3)
Met 458	Metallurgical Design (3)
Phys 340	Heat & Thermodynamics (3)
Phys 431	Theory of Solids (3)
Phys 442	Statistical Mechanics

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 permit students to achieve a breadth of experience in the basic fields of modern science and at the same time, through an option, to acquire the discipline of one of them, about to the level of a minimum bachelor's program. The options and electives offer the student the flexibility by which he may prepare himself for work in industry or government, requiring wide understanding of the basic sciences but not depth in a single field equalling that of a standard major, or he may approach adequacy for graduate study in a field.

The program offers excellent opportunity for a student who is uncertain of his firm desire for a career in a particular standard major to proceed on a broad program which can lead him to a bachelor's degree. If his interest crystallizes in an established field in which he has been taking courses, transfer to that major will normally be possible with only a minimum of dislocation.

Fundamental sciences majors are required to concentrate in a major or recognized hybrids of them: chemistry, physics and mathematics, biology, earth and space science, and science of living systems, materials.

Work in the major science subjects is continuous through all four years. The freshman year is identical with that required of all engineering students. The general studies requirements of the engineering college must also be completed. The discipline of a science will be provided by the inclusion of at least 15 semester hours in his major or from a combination which constitutes the core of one of the inter--disciplinary 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 chairman concerned with the major field of his option.

Freshman Year *(See page 44.)*

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

Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Lab (1)
	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)
	Technical Elective (3)
Math 205	Linear Methods (3)
Phys 21, 22	Introductory Physics II & Lab (5)
	GS Elective (3)

Junior Year, First Semester (16-17 credit hours)

Geol 1	Principles of Geology (3)
	or
Biol 21, 22	Principles of Biology & 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)

	Technical Elective (6)
	Major (6)
	GS Elective (3)

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

	Technical Elective (6)
	Major (6)
	GS Elective (3)
	Elective (3)

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

Phil 42	The Scientific Process (3)
	Technical Elective (3)
	Major (6)
	GS Elective (3)
	Elective (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*
Robert T. Gallagher, D.E.M.
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

E. Everett MacNamara, Ph.D.
Donald F. McLeroy, Ph.D.
Bobb Carson, 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 are 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. In certain cases, equivalent experience is accepted in lieu of attendance at field camp.

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.

Both the B.S. program and the B.A. program provide preparation for graduate school.

B.S. in Geological Sciences (126 credit hours)

College and University Requirements (36 credit hours)

Engl 1	Composition and Literature (3)
	or
Engl 11	Types of World Literature (3)
Engl 2	Composition and Literature (3)
	or
Engl 12	Types of World 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 sicence 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	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Lab (1)
Chem 39	Analytical Chemistry (3)
Chem 196	Physical Chemistry (3)
Phys 11, 12	Introductory Physics I & Lab (5)
Phys 21, 22	Introductory Physics II & Lab (5)
Biol 21, 22	Principles of Biology & 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)
	or
Engl 11	Types of World Literature (3)
Engl 2	Composition and Literature (3)
	or
Engl 12	Types of World Literature (3)

Distribution requirements (See page 34.)

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	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Lab (1)
Chem	Approved elective (3)
Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Lab I (1)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Lab II (1)
Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Lab (1)

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)

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. 1.

101. Earth Materials and Processes (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.

141. Field Geology (3)
Principles and methods of geologic mapping and field work. Preparation of a report and geologic map based on field work by each student in a specific area. Prerequisites: Geol. 23, 33.

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.

302. Geophysical Prospecting (3)
The application of the principles of geophysics to the problems of prospecting. Geophysical instrumentation. Physical and electrical properties of rocks and formations. 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. 3.

315. Regional Stratigraphy (3)
Studies of sedimentary rock sequences in North America illustrating principles of correlation, facies change, methods of environmental and paleogeographic reconstruction. Prerequisite: Senior standing or consent of chairman of department.

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.

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. 3.

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. 3, 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.

354. Elements of Mining (4)
Methods of prospecting and exploration; drilling and blasting; development openings; methods of mining; support of workings. Lectures, recitation, and laboratory. Prerequisite: 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 (Biol., Chem., Geol., or Phys.)

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.

390. Problems of Geology (3)
History and present status of controversial basic geologic problems. Prerequisite: Geol. 312 or consent of chairman of department.

391. Field Seminar (1)
Study of geological problems using field methods of analysis. Field trips, readings, reports, and discussion. Prerequisites: Geol. 23, 315.

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.

In the fall of 1970, 21 M.S. candidates and 5 Ph.D. candidates were enrolled.

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.

Current departmental research activities and special interests include: Geochemistry of phosphate minerals, sulfide mineral phase relations, deoxygenation of crystal surfaces under reducing conditions, Appalachian structure, stratigraphy, Lower Mississippian paleocurrents in Newfoundland, sedimentation during the Laramide Orogeny in the Wyoming Rockies, geology and mineral deposits of the Southern Rockies and Sierra Oriental, carbonate sedimentation, paleoecology of bryozoa, effects of organic films on carbonate equilibrium in sea water, lagoonal sedimentation in New Jersey.

Special departmental research facilities of interest include: Norelco X-ray diffraction unit, Beckman DU spectrophotometer, Beckman infra-red analyzer, Coleman nitrogen analyzer, pH meters, petrographic and binocular microscopes, size analysis equipment for sedimentation studies, chemical balances, hoods, etc., Schmidt-type Askania magnetometer, Worden gravity meter, Gish-Rooney electrical field equipment, standard equipment for geological mapping, Soltzman map projector, furnaces for hydrothermal studies.

401. Seismic Methods (3)
The elements and theory of elastic deformations and wave propagation; refraction and reflection; theory and description of seismographs. Prerequisites: Mathematics through calculus and consent of the instructor.

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.

403. Magnetics and Gravity (4)
Terrestrial magnetism; magnetic properties of rocks and minerals; magnetic instruments. Shape of the earth; gravitational principles and instruments. Prerequisites: Mathematics through calculus and consent of the instructor.

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. Prerequisites: Geol. 312, 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. Tectonics (3)
The major structural features of the earth's crust and the problems of crustal instability; the relationships between major and minor structures; distribution of rock types as related to crustal deformation.

422. Tectonics (3)
Continuation of Geol. 421.

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.

433. Sulfide Phase Equilibria (3)
The thermodynamics of sulfide type ores based on experiments in laboratory systems.

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.

439. Ore Microscopy (3)
Microscopic study of selected ore mineral suites with special attention toward applications of phase equilibria. Prerequisite: Geol. 433.

441. Seminar in Ore Solutions (2)
Presentation of research papers, review of latest literature on the geochemistry and genesis of metallic ore solutions. Offered as required. Consent of the chairman of department.

442. Genesis of Metallic Ores (3)
Research on the genesis of metallic ore suits by use of optical, spectrographic, chemical, etc. methods. One lecture, two laboratories. As required. Consent of the chairman of department.

451. Examination of Mineral Deposits (3)
Systematic exploration and examination; theory of sampling; statistical analysis.

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 aqueous 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.

German & Russian

Professors

John Harms Ubben, Ph.D., *Chairman*
Anna Pirscenok Herz, Ph.D.

Associate Professor

Arthur Parcel Gardner, Ph.D.

Assistant Professors

Douglas A. Waldenrath, Ph.D.
Richard A. K. Watt, Ph.D.

The department of German and Russian offers a major in German. Required courses in the German language and literature constitute a core around which the student can build a program of study providing a broad as well as sound understanding not only of German cultural contributions per se but also as part of the culture of the Western World. Specific courses other than those listed will depend upon each student's previous educational experience; but, in general, collateral work should include ancient and modern European history, fine arts, music, and the languages and literature of other peoples, especially the English, French, Greek, Roman, and Russian.

The sequence of courses offered in Russian is of particular relevance as preparation for careers in teaching and Foreign Service.

Required Preliminary Courses

Ger 1, 2	Elementary German (6)
Ger 11, 12	Intermediate German (6)

Required Major Courses

Ger 31	Conversation and Composition (3)
Ger 43, 44	Types of German Literature (6)
Ger 52	Goethe's Faust (3)
	and at least two of the following:
Ger 32	Conversation and Composition (3)
Ger 202	The German Novelle (3)
Ger 203	Nineteenth Century German Drama (3)
Ger 250	Special Topics (3)
Ger 305	Twentieth Century German Literature (3)
Ger 344	The Age of Goethe (6)

A senior comprehensive examination is required.

German

1. Elementary German (3)
Drill in the fundamentals of German grammar; pronunciation; simple conversation and composition; extensive outside reading of simple vocabulary-building texts. No previous study of German required. As part of their assignment, students are required to attend a one hour laboratory session each week without additional credit.

2. Elementary German (3)
Continuation of Ger. 1. Prerequisite: Ger. 1. As part of their assignment, students are required to attend a one hour laboratory session each week without additional credit.

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)
Reading in Chemistry and Physics. Prerequisites: Ger. 1, or two units of entrance German.

11. Intermediate German (3)
German prose and poetry; outside reading; composition. Prerequisite: One year of college German or two units of entrance German. As part of their work in the course, students are required each week to attend a one hour conversation session without outside preparation and without additional credit.

12. Intermediate German (3)
Continuation of German 11. Prerequisite: Ger. 11. As part of their work in the course, students are required each week to attend a one hour conversation session without outside preparation and without additional credit.

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 German 13. Prerequisite: German 4, or German 13 or consent of chairman of department. 31.

31. Conversation and Composition (3)
Remedial 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.

43. Types of German Literature (3)
Lectures and collateral reading. Prerequisites: Ger. 12, or 4 units of entrance German, or consent of chairman of department.

44. Types of German Literature (3)
Continuation of German 43. Lectures and collateral reading. Prerequisites: Ger. 12 or 4 units of entrance German, or consent of chairman of department.

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 masters degree should have an undergraduate major or its equivalent in German. Those with undergraduate deficiency, though otherwise qualified may be admitted with a stipulation that they make up such deficiencies, in addition to satisfying the minimum requirement for the degree.

The successful completion of ten (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.

202. The German Novelle (3)
Study of the origin and history of the *Novelle* and of contributions by outstanding writers.

203. Nineteenth Century German Drama (3)
Survey of developments and reading of outstanding dramatic works in German literature from the end of the Classical Period through the Age of Naturalism.

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.

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.

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.

331. The Teaching of German in Secondary Schools (3)
The history of teaching of German in the United States, examination of teaching materials, a study of modern methodology, laboratory practice and techniques, and use of experimental classes. Prerequisites: German 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.

381. Cultural Studies (3-6)
A program in Germany, during the summer, for in-service teachers of German and graduate students.

411.George, Rilke and Hofmannsthal (3)
Study of works by three of the greatest 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.

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.

Government

Professors

Charles Allan McCoy, Ph.D., *Chairman*
Donald Delyle Barry, Ph.D.

Associate Professors

Frank Thomas Colon, Ph.D.
Leonard I. Ruchelman, Ph.D.

Assistant Professors

Charles N. Brownstein, Ph.D.
John Loren Washburn, Ph.D.

Instructor

Howard R. Whitcomb, M.A.

The major in government is designed to promote understanding of political ideans, institutions, and practices; to develop skill in the analysis and appraisal of political problems; and to encourage an unbiased consideration of controversial issues in the governmental field. Various courses deal with both the theoretical aspects of government in general and the machinery, processes, functions, and purposes of government in the United States and other countries.

This major is suitable for undergraduates who may become attorneys, social science teachers, government officials, party or civic leaders, public affairs commentators, or staff members of governmental research bureaus. It provides thorough preparation for graduate work in political science and public administration. Graduate study is advisable for students contemplating certain careers, for example: the teaching of political science at the college level; research in the governmental field; and public service as city managers or as administrators at the top and middle management levels of the national and state governments.

Preliminary Courses

Govt 1	American Political System (3)
Govt 3	Comparative Politics (3)

Required Major Courses

Govt 103	Modern Political Philosophy (3)
Govt 321	Scope and Methods of Political Science (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, Pressure Groups and Public Opinions (3)
Govt 302	Comparative State Politics (3)
Govt 351	Constitutional Law (3)
Govt 352	Civil Liberties (3)
Govt 354	Administrative Law (3)
Govt 357	Urban Politics (3)
Govt 359	Legislative Process (3)
Govt 360	Public Administration (3)

Political Theory—Comparative Politics

Govt 76	Asian Political Systems (3)
Govt 308	Classical Political Heritage (3)
Govt 318	Communist Political Systems (3)
Govt 316	American Political Ideas (3)
Govt 322	Politics of Developing Nations (3)
Govt 362	The Soviet Political System (3)
Govt 363	Contemporary Political Philosophy (3)
Govt 364	Contemporary Political Analysis (3)

In addition to the recommended major program the government department has approved an unstructured government major based on 33 hours of government courses, 15 of them being at the upper level. Interested students should see the chairman for details.

Urban Studies Option in Government

The government major is eligible to participate in the Urban Studies Program which is a multi-disciplinary focus on the urban process. Interested students should refer to Social Relations for details.

Undergradute 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, Pressure Groups and Public Opinions (3)
The organization, functions and techniques of political parties and pressure groups; nomination and election methods, voting behavior and public opinion; government and politics. Prerequisite: Sophomore standing.

76. Asian Political Systems (3)
The governmental and political systems of Asian societies. Major attention will be given to the political cultures and systems of India, China, and Japan. Prerequisite: Sophomore standing.

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.

308. Classical Political Heritage (3)
The contribution of significant political theorists from Plato to Machiavelli.

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.

318. Communist Political Systems (3)
An examination of the political systems of communist states other than the USSR and of the operations of non-ruling communist parties.

321. Scope and Methods of Political Science (3)
Introduction to the philosophy of the social sciences; approaches to the study of politics; the limits of political analysis; research design and techniques; political bibliography; field study.

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.

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.

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.

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.

357. 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 politics of municipal reform; city planning and urban renewal.

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.

361. Comparative Administrative Systems (3)
Problems concerning governmental organization and administration; the implementation of public services in selected countries. Comparison of administrative procedures in various jurisdictions or bodies politic with those in the U.S.

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)
Discussion of theories for analyzing and evaluating conflicts in political systems; review of approaches to conflict resolution processes. Concepts from political and social science, behavioral science, physical science.

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 insitution, 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 masters 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 multidisciplinary 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. Masters degree candidates in government can declare an option in the area of Urban Studies. This is a multidisciplinary 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, Metropolitan Politics, 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 interpresonal awareness; (d) a general examination tailored to the D.A.: (e) a research project dealing with problems of teaching and learning in government rather than a dissertation and (f) a supervised internship in college teaching.

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 313	Teaching Government (3)
Govt 314	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; sub-national 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 shoould 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 (6 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. The progress of interns will be monitored systematically by direct observation of teaching performance and evaluation of his syllabus, examinations and grading procedures.

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.

Drawing on his teaching and community organization internships, the student will develop a new course on a relevant subject. The substantive materials and theoretical underpinnings of this course plan will be defended by the student before a committee appointed by his project advisor.

Examination

Those students entering the D.A. program without the masters 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 for internship.

411. The Development of Political Philosophy (3)
A study of recurring themes of political thought, such as justice, the nature of political authority, freedom, and equality. Special attention will be given to selected aspects of theoretical concern about the foundations of politics such as the political ideas of ancient Judaism, of Christianity, and classical political theories.

412. The Revival of Political Philosophy (3)
Analysis of the principal movements in recent political thought, such as positivism, logical positivism, historicism, and behavioralism. The revival of inquiry into the nature of political thought and action, including discussion of the philosophical concepts and moral principles presupposed by political analysis.

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. Field Research in Political Science (3)
A study of the important literature in political science based directly on field research. An examination of the techniques employed. Limited supervised field research will be conducted.

422. Systems Approaches in Political Science (3)
An examination of the major systems analysts in political science such as Easton, Deutsch, Meehan, Almond, Kaplan, Brody, Haas, Scott. Projects in system construction.

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.

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.

462. Metropolitan Politics (3)
The scope and methods of research on the community level. Systematic, empirical inquiry into the politics of communities and between communities is stressed.

481. Special Topics (3)
Individual inquiry into some problems of government other than the subject of the master's thesis. Reading, field work, and other appropriate techniques of investigation. Conferences and reports.

482. Special Topics (3)
Continuation of Govt. 481.

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.

Associate Professors

John H. Ellis, Ph.D.
George Mark Ellis, Ph.D.
William Gerald Shade, Ph.D.

Adjunct Professor

Edward Lurie, Ph.D.

Adjunct Assistant Professor

Christa V. Graf, Ph.D.

Assistant Professors

Pierre Juliard, Ph.D.
James S. Saeger, Ph.D.
Roger D. Simon, M.A.

Lecturers

Burns V. Machobane, M.Ed.
Julius Nimmons, M.A.

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 viewed contemporary problems by studying forces in the past which have shaped our present 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 judgements, 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. In the senior year, majors must take the senior seminar.

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 Major Courses

Twenty-four hours chosen from the following:

Hist 21, 22	Ancient History (6)
Hist 319	Colonial America (3)
Hist 320	Revolutionary America (3)
Hist 323, 324	American Constitutional History (6)
Hist 325	American Immigrant History (3)
Hist 327, 328	American Intellectual History (6)
Hist 329, 330	American Foreign Policy (6)
Hist 331	The Negro In America (3)
Hist 333, 334	American Urban History (6)
Hist 335	United States, 1789-1840
Hist 336	United States, 1840-1877
Hist 337	United States, 1877-1920
Hist 338	United States, 1920 to Present (3)
Hist 343	English History, 1471-1660 (3)
Hist 344	English History, 1660-1789 (3)
Hist 345	Liberal England (3)
Hist 346	Socialist England (3)
Hist 347, 348	The British Empire (6)
Hist 349, 350	The Middle Ages (6)
Hist 355, 356	European Intellectual History (6)
Hist 357	The Renaissance and Reformation (3)
Hist 358	The Age of the Baroque (3)
Hist 359, 360	Modern Europe (6)
Hist 361	A History of Russia to 1855 (3)
Hist 362	A History of Russia, 1855 to Present (3)
Hist 365	Colonial Latin America, 1492-1825 (3)
Hist 366	Modern Latin America, 1825 to the Present (3)
Hist 367	The Iberian Peninsula (3)
Hist 368	The Caribbean (3)
Hist 371, 372	Special Topics in History (6)
Hist 374	Themes in American History (3)

History majors are encouraged to enroll in courses in economics, English and American literature, government, international relations, philosophy, psychology, 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)
An examination of civilizations in the East, West, and Africa from earliest times to 1700.

2. Course of Civilizations (3)
An examination from 1700 to the present of civilizations in the East, West, and Africa.

13. American Civilization (3)
History of American civilization to 1865, emphasizing the development of our cultural heritage. Puritanism; Deism; American Revolution; Constitution; Jeffersonian and Jacksonian Democracy; Abolitionism and Civil War.

14. American Civilization (3)
American civilization since 1865. Industrialism; Urbanization; Social Darwinism; Pragmatism; the Frontier; Progressivism and the New Deal; the two World Wars.

15. English History (3)
An introduction to 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 will be examined.

16. English History (3)
The development of 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 will be studied.

21. (Greek 21) Ancient History (3)
For course description, see Classics.

22. (Latin 22) Ancient History (3)
For course descripton, see Classics.

49. History of Latin America (3)
A survey of the 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.

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.

For Advanced Undergraduates and Graduates

319. Colonial America (3)
A study of the 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.

320. Revolutionary America (3)
A study of American political, economic and cultural development from the mid-eighteenth century through the adoption of the Federal Constitution.

323. American Constitutional History (3)
The development of American constitutional thought and practice from the colonial period to the Civil War. Consideration of governmental institutions, political parties, and legal thought in the context of American history; special emphasis upon the Confederation, the Constitution, and the states-rights controversy.

324. American Constitutional History (3)
Constitutional thought and practice from the Civil War to the present. Consideration of the new role of government, problems caused by the Industrial Revolution, and modern issues relating to personal liberties and federal-state relations.

325. American Immigrant History (3)
Immigration in American history. The changing sources of American immigration; successive "First generations" and the process of ethno-cultural transfer; cultural stability and change through post-immigrant generations; "minority groups" in American political history.

327. American Intellectual History (3)
A study of the development of political, social, and religious ideas in America from the colonial period to the Civil War. Prerequisite: Consent of chairman of department.

328. American Intellectual History (3)
A study of economic, political, and religious thought in industrial America, 1860 to the present. Prerequisite: Consent of chairman of department.

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 19[illegible]

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." Prerequisite: Consent of chairman of department.

333. American Urban History to 1880 (3)
The city in American history from colonial times to 1880. Colonial maritime centers, New York's rise to preeminence, urban imperialism and regional rivalries, changing transportation patterns and diffusion of urban sites, and early industrial cities. Prerequisite: Consent of chairman of department.

334. American Urban History, 1880 to Present (3)
The city in American history since 1880. Industrialization and urban social structure, new urban technology, "reformers" vs. "bosses," social welfare and social control, suburbanization, declining localism and the rise of an urban mass society. Prerequisite: Consent of chairman of department.

335. United States, 1789-1840 (3)
Development of 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.

336. 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.

337. United States, 1877-1920.
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.

338. United States, 1920 to present (3)
Development of 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. Prerequisite: Consent of the chairman of department.

343. English History, 1471-1660 (3)
The evolution of England under the Tudor monarchy and the problems facing its successors culminating in the Civil Wars and Interregnum. Special emphasis will be placed on political, economic, intellectual and religious developments of the period.

344. English History, 1660-1789 (3)
The development of constitutional monarchy from the Stuart Restoration to the French Revolution. English civilization in an age of oligarchy will be examined especially in 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.

347. The British Empire (3)
The expansion of the English-speaking people from 1603 to 1848; the origins of self-government; the founding of the Empire in Asia and Africa; the role of Great Britain in world affairs.

348. The British Empire and Commonwealth (3)
The expansion of the Empire in Asia and Africa since 1848; the growth of federalism and self-government; the independence movements in Ireland and India; the formation of the Commonwealth; the impact of two World Wars; the decline of the Empire since the Second World War.

349. The Early Middle Ages (3)
An analysis of European institutions and cultural developments from 284 A.D. to the mid-eleventh century. Emphasis upon the evolution of the Church, feudalism and manorialism, the foundations of the Byzantine, Carolingian, and Holy Roman Empires, and the literary and artistic achievements of the period.

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 in late medieval society.

355. European Intellectual History (3)
A study of political and religious thought and other aspects of the history of ideas in Europe from the Middle Ages to about 1700. Prerequisite: Consent of chairman of department.

356. European Intellectual History (3)
A continuation of History 355, with special attention given to the impact of the Industrial Revolution upon thought and to the development of nineteenth- and twentieth-century ideologies. Prerequisite: Consent of chairman of department.

357. The Renaissance and Reformation (3)
An analysis of the transition from medieval to modern society. Consideration will be given to political, economic, and social forces produced by the Renaissance and the influence of these upon the dominant religious theme of the Reformation era.

358. Age of the Baroque (3)
A study of Europe from 1648 to 1789. The course will treat the growth of absolutism in France, the rise of Prussia, and the social and political and economic conditions in the eighteenth century.

359. Modern Europe (3)
The study of revolutions and reactions in Western Europe from 1789 to 1870. Emphasis is placed on rise and spread of liberalism and the origins of socialism.

360. Modern Europe (3)
A study of contemporary Europe; the origins and consequences of two World Wars; the rise of revolutionary governments in Italy, Germany, and Russia.

361. A History of Russia to 1855 (3)
An analysis of the 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 information and consolidation of the Soviet dictatorship.

365. Colonial Latin America, 1492-1825 (3)
Individual investigation and reports on selected topics. Emphasis upon the Spanish concept of empire, church-state relations, origins of the Wars of Independence. Prerequisite: History 49, 50, or consent of chairman of department.

366. Modern Latin America, 1825 to the Present (3)
Individual investigation and reports on selected topics. Emphasis upon nationalism, conservatism, and liberalism in the nineteenth century; the rightist revolutions, socialism, and communism in the twentieth century. Prerequisite: History 49, 50, or consent of chairman of department.

367. The Iberian Peninsula (3)
A study of Spain and Portugal from the eighth century to the present, emphasizing the historical influence of Iberian culture on the development of colonial institutions. Prerequisite: One year of college Spanish or its equivalent and consent of chairman of department.

368. The Caribbean (3)
A study of political and social developments from pre-Columbian times to the present with primary emphasis upon the growth of liberalism and nationalism 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 field of research may be varied from time to time and 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 aim of the seminar will be to allow study of an aspect of American history in greater depth than is generally the case. Prerequisite: Permission of director of American Studies.

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, British, Europe to 1789, Europe since 1789, and Latin American history.
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. An original dissertation is required and may be written only in a primary field.
Primary Fields. Primary fields are Great Britain, Colonial America and United States since 1789.
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. A study of 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)
This course is 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)
This course is 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 Professor

Mikell Porter Groover, Ph.D.

Instructors

M. Wayne Shiveley, M.S.
Emory W. Zimmers, Jr., M.S.
David D. Hott, M.S.
Lynne H. Hott, 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 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 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 44.)*

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)
	Elective (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 (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 (3)

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

IE 154	Project (3)
IE	Electives (6)
	GS Electives (6)
	Elective (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.

17. Introduction to Computing (3)
Basic computer concepts; algorithms and program logic; procedure oriented systems; principles of validation; computer solution to problems. Math. 23 concurrently.

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.

121. Analysis and Design I (5)
An intensive study of the planning activities of industrial engineering, including manufacturing planning, product design analysis, process selection, operation planning, production control, engineering economy. Prerequisite: Math. 231.

122. Analysis and Design II (4)
Techniques for analysis and design of man and machine work systems and application to typical problems in work measurement. Time study, predetermined time systems, work sampling, and development of standard data. Control of methods and standards. Materials handling and plant layout. Prerequisite: I.E. 121 and 221.

152. Project (2)
Special study of a particular problem involving laboratory work and/or work in local industrial plants. Prerequisite: Senior standing in Industrial Engineering.

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 the student not majoring in I.E. Study of functions involved in manufacturing planning and control, including production scheduling, inventory control, quality control, work measurement, methods analysis, and production systems analysis. Prerequisites: Math. 21, 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.

221. Industrial Statistics (4)
Techniques of hypothesis testing, including analysis of variance and distribution free methods; estimation, including regression and prediction. Elementary principles of planning samples. Design of experiments and construction of decision rules. Prerequisite: Math. 231.

222. Operations Analysis and Design (4)
The development and use of techniques of Operation Analysis. Topics include linear programming, queuing theory, probabilistic inventory models and simulation. Prerequisites: Math. 231, Math. 205.

241. Fundamentals of Production Engineering (3)
Study of metal processing theory, product design analysis and processing equipment capabilities. Laboratory experiments.

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 (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.

333. Organization and Administration (3)
Theory of organization; policies and procedures for administrative control with emphasis on industrial engineering functions; influence of human relations and management information on decision-making. Prerequisites: I.E. 102 or I.E. 166.

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.

339. Industrial Manpower Management (3)
A study of policies and procedures involved in analysis and design of manpower planning and control; study of utilization of human resources on the job with emphasis on wage administration. Lectures, case problems, projects. Prerequisite: I.E. 102 or 166.

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, the courses required in the major field may include a maximum of nine hours from the following two groups with no more than six hours from each group:

(1) 400-level courses in other branches of engineering;

(2) Eco. 431, Managerial Economics; Eco. 433, Labor Management Economics; Acctg. 422, Managerial Accounting; Psych. 455, Engineering Psychology; I.S. 421, Analysis of Information. 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 the University 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 operation 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: A course in data processing and consent of chairman of department.

409. Industrial Engineering Standardization (3)
Identification of the basic variable that exists in industrial engineering, problem-solving techniques, and investigation of the means for standardization of these variables. Techniques analyzed for standardization include motion and time study, metal process planning, statistical quality control, and production planning and control.

410. Design of Experiments (3)
Fixed, mixed, and random models, fractional factorials, unequal cell frequencies. Sequential design for estimation and optimization. Prerequisite: I.E. 336 or 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: Integer programming, parametric linear programming, non-linear programming, dynamic programming, duality theory and network theory. 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; dynamic simulation by digital computers for analysis and evaluation; optimization of production systems; interaction of physical system and information system; significance of system parameters.

426. Inventory Theory (3)
Optimal policies in deterministic inventory processes; optimal policies in stochastic inventory processes; operating characteristics of inventory policies. Prerequisite: I.E. 311 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: I.E. 311 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 analysis.

431. Manufacturing Engineering 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.

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*
Oles M. Smolansky, Ph.D.

Adjunct Professor

Percy Elwood Corbett, M.A.

Associate Professors

Henderson Bampfield Braddick, Ph.D.
Auric Nichols Dunlap, Ph.D.

Instructor

Frederick Robert Gladeck, M.A.

The field of international relations poses an unprecedented challenge to student and teacher alike and provides a stimulating focus of interest for undergraduate education. It demands full recognition and understanding of the vast forces which are shaping the world—wars, nationalism, political ideologies, and modern technology. The leadership and responsibilities of the United States in the world arena have created a need for broadly educated young men and women who possess a clear appreciation of the factors which influence the politics 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 and principles involved in an understanding of international politics. The main focus will be upon nationalism, the balance of power, alliances, the nature of conflict, and the limits of peaceful changes.

2. World Politics (3)
An introduction to the foreign policies of the great powers: United States, Soviet Union, Britain, France, Germany, Japan, India, and China.

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 Russian 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

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.

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.

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)
Continuation of I.R. 341. 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

Thirteen students currently are pursuing the Master of Arts 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, College of Business*
Eli Schwartz, Ph.D.
L. Reed Tripp, Ph.D.

Associate Professors

Leon Elwood Krouse, Ph.D.
Benjamin Litt, Ph.D.
Max Donald Snider, M.B.A.
Gary E. Whitehouse, Ph.D.

Assistant Professors

Carl R. Beidleman, Ph.D.
Bruce M. Smackey, Ph.D.
Charles F. Vihon, D.J.

Adjunct Professors

Harry A. Dower, LL.B.
Reese D. Jones, M.S.
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	Corporation Financing (3)
Eco 129	Money and Banking (3)
Eco 45	Statistical Method (3)
Acctg 108	Fundamentals of Accounting (3)

Required Major Courses

Fin 323	Investments (3)
	or
Fin 324	Security Analysis (3)
Fin 326	Problems in Financial Management (3)
Eco 353	Public Finance: Federal (3)
Eco 316	Intermediate Macro-Economic Theory (3)
	or
Fin 322	Monetary–Fiscal Policy (3)
	plus six hours from the following:
Fin 324	Security Analysis (3)
Eco 316	Intermediate Macro-Economic Theory (3)
	or
Fin 332	Monetary–Fiscal Policy (3)
	plus six hours from the following:
Fin 323	Investments (3)
	or
Fin 324	Security Analysis (3)
Eco 316	Intermediate Macro-Economic Theory (3)
	or
Fin 332	Monetary–Fiscal Policy (3)
Fin 340	International Finance (3)
Fin 331	Bank Management (3)
Fin 330	Financial Flows and Markets (3)
Fin 354	Public Finance: State and Local (3)

Major in Business and Economics College

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

Fin 323	Investments (3)
Fin 326	Problems in Financial Management (3)
Fin 353	Public Finance: Federal (3)
	and six credits from the following:
Fin 324	Security Analysis (3)
Fin 331	Bank Management (3)
Fin 332	Monetary–Fiscal Policy (3)
Eco 339	International Economics (3)

For Advanced Undergraduates and Graduates

225. Principles of Corporation 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.

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: Senior standing.

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. 125 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.

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.

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)
A course designed to deal with 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 102.

Management

Majors in Business and Economics

Required: 15 credit hours beyond the Core listed on page 40.

Mgt S 301	Business Management Policies (3)
Mgt S 302	Survey of Management Science Applications (3)
	or
Mgt S 321	Business and Organizational Behavior (3)
	whichever was not taken in the Core and
	9 credits from either of the following options:
	Quantitative Analysis Option (9)
Mgt S 314	Operations Analysis (3)
Eco 352	Advanced Statistical Method (3)
Acctg 311	Accounting Information Systems (3)
	Organizational Behavior Option (9)
Eco 335	Manpower Economics (3)
	or
Eco 338	Labor Market Institutions (3)
Psych 201	Industrial Psychology (3)
	or
SR	Course Approved by Advisor (3)

Undergraduate Courses

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 to be supplemented by case studies, Management Business Simulation Game 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, waiting line (Queuing), 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. S. 302. Development of term projects to solve practical problems. Prerequisite: Mgt. S. 302.

314. Operations Analysis (3)
Intensive coverage of theoretical development underlying linear and integer programming, classical optimization, input-output analysis, cardinal utility, and game theory. Designed for doctoral candidates, and as background for Mgt. 417-418 sequence. Credit may not be received for Mgt. 302 and Mgt. 314. Prerequisites: Eco. 45, Acctg. 111, and one semester of calculus.

321. Business and Organizational Behavior (3)
An analysis and survey of various theories of organization: management theory, concepts, and practices; human resources development.

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 rostered courses. Prerequisite: Preparation in management acceptable to the department chairman. May be repeated for credit.

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. Seminar in Organizational Behavior (3)
An analysis of organizational character, structure, processes, and interpersonal relations as they are related to the behavior of individuals as members of groups. Emphasis is upon business organizations. Prerequisite: Mgt. 321 or its equivalent.

417. (I.E. 417) Advanced Mathematical Programming (3)
Theory and applications of the extensions of linear programming; Integer programming, parametric linear programming, non-linear programming, dynamic programming, duality theory and network theory. Prerequisite: Mgt. 302 and Mgt. 304, or Mgt. 314 or equivalent.

418. Seminar in Management Science (3)
Theory of applications of operations research methods and models such as: Inventory, waiting line, simulation, net-work theory, PERT and heuriatic programming. Applications in accounting, finance, marketing, and community services. A practical project is carried out by the students. Prerequisites: Mgt. 302 and 417.

451. Managerial Policy and Decision-Making (3)
Integration of theory and analytic techniques through the intensive investigation of complex economic and financial problems and issues in corporation. 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 alternative. Prerequisites: graduate level exposure to accounting, economics, finance, management and marketing. An MBA student should undertake 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 credit hours beyond the Core listed on page 40.

Mkt 211	American Marketing System (3)
Mkt 213	Marketing Communications (3)
	or
Mkt 220	Behavioral Aspects of Selling (3)
Mkt 312	Marketing Research (3)
Mkt 315	Consumer Behavior (3)
	One of the following((not taken in the Core)
Mgt S 302	Quantitative Models - Conceptual (3)
Mgt S 321	Business and Organization Behavior (3)

Recommended Electives

Mgt S 301	Business Management Policies (3)
Eco 338	Labor Market Institutions (3)
Psych 106	Motivation (3)
	or
Psych 302	Theories of Personality (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, the formation, performance, and dissolution of channels of communications, and the 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 or equivalent background.

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.

371. Directed Readings (1-3)
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.

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: Three hours of graduate coursework in marketing, or the equivalent.

450. Entrepreneurial Marketing (3)
Managing the marketing function from the perspective of developing new consumer and industrial products, new markets, and new enterprises which emerge from new technological knowledge. A case method approach is used. Prerequisite: Mkt. 211.

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.
Gary Bernard Laison, Ph.D.
Robert W. Johnson, Ph.D.
Donald L. Prullage, Ph.D.
Peter Jules Richetta, Ph.D.
Herbert Bancroft Skerry, Ph.D.
Ruth Silverman, Ph.D.
Douglas Henley Taylor, Ph.D.

Lecturer

Marguerite B. Gravez, M.A.

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

M th 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. Prerequisite: Math. 21 or 41, previously or concurrently.

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.

54. Advanced Geometry (3)
An introductory course in projective geometry and non-euclidean geometry. Prerequisite: Math. 22 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.

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 course will examine 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.

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.

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 group, simplicial and singular homology. Prerequisite: 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.

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 Math. 221 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.

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.

373. (I.S. 373) Mathematical Methods in the Information Science (3)
For course description, see I.S. 373.

381. Probability and Statistics (3)
Combinatorial problems, theory of probability, various frequency distributions, standard derivation, 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

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 1970 there were about sixty graduate students of mathematics, of whom about twenty 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 required 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.

401. Real Analysis I (3)
Spaces of continuous functions; the Lebasgue integral; differentiation; general theory of measure and integration; Banach and Hilbert spaces; *Lp*-spaces. Applications to such topics in classical analysis as integral equations and Fourier series. Prerequisite: Math. 307 or consent of 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 hyperbolic 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 geomtery 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. Prerequisite: 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 automophisms. Prerequisite: Math. 428.

Division of Astronomy

Associate Professor

George E. McCluskey, Ph.D.

1. Descriptive Astronomy (3)
The earth as an astronomical body; the solar system; a brief introduction to sidereal astronomy.

104. Stellar Astronomy and Astrophysics (3)
Introduction to astrophysics; the sun considered as a star; physical characteristics of the stars; stellar motions; binary star; theory of binary star orbits; stellar aggregations; cosmogony. Prerequisites: Math. 22 and Phys. 16 or Phys. 3.

250. Topics in Astronomy (3)
A course covering one or more topics not covered in other courses. Prerequisite: Consent of the chairman of department. May be repeated for credit.

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.
Fazil Erdogan, Ph.D
George Franklin Irvin, Ph.D., *Boeing University Professor*
Thomas Edgar Jackson, M.S.
Arturs Kalnins, Ph.D.
Jerzy Antoni Owczarek, Ph.D.
Paul Croce Paris, Ph.D.
Ronald S. Rivlin, Ph.D., *Centennial University Professor*
George C. M. Sih, Ph.D.
Gerald Francis Smith, Ph.D.
Alan Hugh Stenning, Sc.D.
Eric Varley, Ph.D.
Robert Peh-Ying Wei, Ph.D.

Associate Professors

James Vandeusen Eppes, M.S.
Robert Alan Lucas, Ph.D.
Alistair Kenneth MacPherson, Ph.D.
Joseph C. Osborn, M.S.
Richard Roberts, Ph.D.
Eric P. Salathe, Ph.D.
Robert Guy Sarubbi, Ph.D.
Theodore Alfred Terry, Ph.D.

Assistant Professors

Vahram Biricikoglu, Ph.D.
George Tyler Embley, Ph.D.
Ronald John Hartranft, Ph.D.
Peter D. Hilton, Ph.D.
Edward Kenneth Levy, Ph.D.
James Peter Ries, Ph.D.
Dean Pearson Updike, Ph.D.

Instructor

Walter Barry Wagner, M.S., M.E.

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 a training, in which applied mathematics and mechanics play an important part, is provided by the engineering problems and the applications to their solution of the basic methods and principles of mechanics.

Graduates in either disciplines 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 degrees 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 44.)

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)
Met 63	Engineering Materials (3)
Eco 1	Economics (4)

Junior Year, First Semester (18 credit hours)

ME 101	Mechanical Engineering Design (3)
Mech 102	Dynamics (3)
ME 105	Thermodynamics II
	or
	Approved Elective (3)
Math 208	Complex Variables
	or
Math 231	Statistical Inference (3)
	GS Requirement (6)

Junior Year, Second Semester (15 credit hours)

ME 231	Fluid Mechanics (3)
CE 123	Fluid Mechanics Lab (1)
ME 242	Mechanical Vibrations (3)
Mech 203	Advanced Strength of Materials (3)
EE 160	Electrical Circuits & Apparatus (3)
EE 161, 162	Electrical Problems & Lab (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 (3)

Senior Year, Second Semester (14-17 credit hours)

ME 109	Laboratory II (2)
	Approved Electives (9)
	GS Requirement (3)
	Elective (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 (3)
A project oriented course to develop student capability in mechanical engineering design. Design methodology, the functional behavior of mechanical elements, and engineering problem modeling. Special attention is given to defining design problems, organizing information, proposing solutions and evaluating alternatives.

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: ME 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. Application of the engineering sciences in the performance prediction of selected mechanical engineering systems. Digital and analog computer simulation studies. 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. Single degree of freedom systems under free, forced and transient loading conditions. Lagrangian and matrix formulations for multiple degree of freedom systems. Simple continuous and non-linear systems. Engineering applications. Prerequisite: Mech. 102 or 103.

310. Projects (3-6)
Analysis and synthesis of selected mechanical engineering systems and devices. Case studies chosen from topics such as design of fluid machinery, power plants, internal combustion engines. Consideration of mechanical design and thermodynamic influences, with emphasis on the creative phase of design. 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, equations of flow in integral form, and two dimensional potential flow theory of incompressible fluids with applications. Navier-Stokes equations, dynamic similarity, laminar flows, turbulence, and boundary layers. Introduction to flow of compressible fluids. Measurement techniques. Flows in and performance analysis of turbomachinery; introduction to the design of cascades. Flow of non-Newtonian fluids. Hydrodynamic lubrication. Prerequisites: M.E. 231 and C.E. 123.

340. Advanced Mechanical Engineering Design (3)
Design of mechanical systems and components requiring applications of advanced principles of mechanics and material behavior. Advanced design topics, including optimization, reliability and sensitivity analysis. Prerequisite: Math. 231.

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 all 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 propogation 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 wider 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, mechanics synthesis, digital and analog computer-aided design, ocean engineering, bio-mechanic and optimum 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, stability and propagation; related problems in compressible flow involving one-dimensional, oblique shock waves and detonations waves. Methods of measurement and instrumentation.

423. Boundary Layer Analysis (3)
Navier-Stokes equations, laminar boundary layer theory, analysis of friction drag, heat transfer and separation; transition form laminar to turbulent flow. Turbulent boundary layer theory, Karman integral equations, Prandtl mixing length, turbulent friction drag, heat transfer and layer thickness. Flow in ducts, waves and jets.

425. Convective Heat Transfer (3)
Development of the differential and integral boundary layer equations. Laminar external forced convection, flows with pressure gradients; effect of nonuniform wall temperature. Turbulent external forced convection. Laminar forced convection tube flow: entry length problems. Turbulent forced convection tube flow. Effect of variations in fluid properties. Heat transfer at high velocities. Natural convection heat transfer. Low density heat transfer. Transient convection. Film convection. Prerequisite: M.E. 321 or Ch.E. 421.

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 co-current 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.

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 mixtures 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, previously or concurrently.

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, 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, Mech. 302, or E.E. 212.

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. Prerequisite: Mech. 1; Math. 23, previously or concurrently.

13. Materials Testing Laboratory (1)102. Dynamics (3)
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 to 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; mechanical vibrations. Prerequisite: 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 patterns in solids and liquids, the Griffith Theory and extensions to linear elastic fracture process models; stress analysis of cracks; plasticity, fatigue, corrosion and temperature effects; fracture toughness testing 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 through 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 electromechanical interactions. Stress birefringence. Wave propagation. Finite amplitudewave 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 microstructure 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 (3)
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) Theory of Dislocations (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 for Research*
Betzalel Avitzur, Ph.D., *Director, Institute for Metal Forming*
Ye Tsand Chou, Ph.D.
Ralph Wayne Kraft, Ph.D.
Alan Wiggins Pense, Ph.D.
Richard Moore Spriggs, Ph.D.
Robert Daniel Stout, Ph.D.
David Alden Thomas, Ph.D.

Associate Professors

Sidney Roy Butler, Ph.D.
Joseph Irwin Goldstein, Ph.D.
Walter Charles Hahn, Jr., Ph.D.
D. P. H. Hasselman, Ph.D.
Richard Warren Hertzberg, Ph.D.
George Krauss, Jr., Sc.D.
Donald M. Smyth, Ph.D.
Stephen Kenneth Tarby, Ph.D.
John Dudley Wood, Ph.D.

Assistant Professors

Michael Richard Notis, Ph.D.
Donald Lawrence Ritter, Ph.D.

Progess 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 larger 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 44.)

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 (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 (5)
Phys 31	Introduction to Quantum Mechanics (3)
Mech 1	Statics (3)
Met 10	Metallurgy Lab
	or
Mech 13	Materials Testing Lab (1)
	GS Elective (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 (3)

Junior Year, Second Semester (16-17 credit hours)

ME 166	Procedures for Mechanical Design
	or
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)
	GS 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)
	Elective (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 (3)

Note: Engineering Science Electives are to be chosen from Ch.E. 41, 52, 320, 321; E.E. 11, 20, 103; Mech. 102, 203, 313; Met. 312, 333, 334.

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

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	Structures and Behavior of Materials (3)
Met 313	Materials Fabrication (3)
	Elective (3)

Senior Year, Second Semester (17 credit hours)

Chem 196	Physical Chemistry (3)
Met 338	Metallurgy Colloquium (2)
Met 358	Selection of Materals (3)
Met	Approved Elective (3)
	GS Elective (3)
	Engineering Science Elective (3)

Note: Engineering science elective to be chosen from Ch.E. 41, 52, 320, 321; E.E. 11, 20, 103; Mech. 102, 203, 313; Met. 312, 333, 334.

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

Research Options

For those students whose interests lie in the fields of theoretical or materials science, and who intend to pursue graduate work, a research option is offered. In this option, students are required to take Met. 240 and 291. Financial support is 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

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)

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 fabrications and treatment. Application and use of materials in engineering. Primarily metals, but including plastics, ceramics, and other engineering materials. Prerequisites: Chem. 3 or 13; Phys. 16 or 1.

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. 3, 13 and Phys. 3 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)
Meeting 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, Met. 63 or Met. 91, 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.

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.

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 Fabrications (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. 208 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: Met. 63 or Met. 91.

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
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. 4, Met. 91 or equivalent.

334. (Geo. 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

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 research may be a part of programs underway 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 philosphy degrees in 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 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.

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.

A number of graduate students in metallurgy and materials science do their thesis work in the Materials Research Center. The list of research activites notes the many areas of interest and the asterisks indicate research of an interdisciplinary nature. Examples of departmental research activities include:

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
Eutectic research including solidification, microstructure, and property studies*
Magnetic materials
Meteorites
Photoelectric studies of insulators
Preparation and properties of materials for solid state devices*
Processing of metal insulator semi-conductor structures and their evaluation and application to integrated circuits*
Quantitative metallography
Solidification of tool steels
Structure and behavior of solid state materials*
Structure and properties of sputtered, evaporated, and plated thin films*

Mechanical Metallurgy
Cladding and forming of composite materials
Correlation of microstructure with mechanical behavior of low-alloy high-strength steels, especially fatigue, creep and brittle fracture
Deep drawing, impact extrusion and ironing
Deformation and fracture of eutectic composites
Ductile fracture
Effect of holes, inclusions and pressure on the tensile properties
Electron fractography*
Environmental crack kinetics*
Fatigue crack propagation studies of metals and polymers*
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 system*
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
Pressure-sintering kinetics of ceramics
Static and cyclic fatigue of ceramics
Strengthening mechanisms in impregnated porous brittle materials
Strengthening mechanisms of glasses and ceramics by surface compression
Synthesis and characterization of polycrystalline diamond compacts
Synthesis, characterization and densification kinetics of ultra-fine ceramic powders
Theoretical analysis of deformation, fracture and flow characteristics of brittle materials
Thermal stress fracture and spalling mechanisms in brittle ceramics*
Thermoviscoelastic behavior of ceramics and glasses*

Physical Metallurgy
Creep-rupture and aging, and 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 (3)
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.

402. Metallurgical Investigation and Thesis (3)
Continuation of Met. 401.

404. Materials for Modern Technology (3)
Detailed study of the chemical, mechanical and physical behavior of one or more of the materials in modern technology, such as cryogenic, nuclear, or aerospace technologies. This course may be repeated for credit beyond three hours with permission of the instructor. Prerequisites: Met. 208 and Met. 218, Met. 305 or consent of chairman of department.

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. The Principles of Modern Welding (3)
The foundations upon which the welding processes rest; the present limitations of the various processes; the trends in new developments; the engineering and metallurgical aspects of welding. Prerequisite: 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 chairman of department.

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.

421. Surface Treatment of Metals (3)
Study of metallic surfaces. Preparation of surfaces by machining, grinding, polishing; methods of surface hardening; corrosion and surface protection of metals; analysis of surface stresses as related to fatigue life. Prerequisite: Met. 307.

425. Sintering and Related Phenomena (3)
Kinetics and mechanisms of sintering and grain growth of powdered materials. Powder characterization. Compaction phenomena. Application and behavior of fabricated metal, ceramic, and polymer shapes. Prerequisites: Met. 208, Met. 218. Desirable preparation: Met. 315, Chem. 392.

433. X-ray Metallography (3)
Scattering theory using the interference function and reciprocal lattice concepts. Diffuse scattering of X-rays and the radial distribution method, including applications. Brief treatment of crystal structure determination. Structural evaluation of materials by X-ray topographic, X-ray microscopic, and microradiographic methods. Prerequisite: Met. 333.

437. (Mech. 437) Theory of Dislocations (3)
The mathematical theory of dislocations. Geometrical interpretation; elastic properties of dislocations; force in a dislocation; dislocation interactions and reactions; multiplication. Dislocations in crystal structures. Applications to plastic flow, creep and fracture. Prerequisites: Math. 205 or 221, or Met. 320; Met. 317; or consent of the chairman of the department.

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.

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 1660 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)
Intensive study of works for various media of Haydn, Mozart and Beethoven, with emphasis on form and style. Prerequisite: Mus. 31 or 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: Mus. 31 or 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.

Required Preliminary Courses

Math 21,22,23	Analytical Geometry and Calculus (12)
Phys 11,12	Introductory Physics I & Lab (5)
Phys 21,22	Introductory Physics II & Lab (5)
Chem 21,22	Introductory Chemical Principles & Lab (5)
Geol 1	Principles of Geology
	or
Astro 1	Descriptive Astronomy (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

Professors

Donald John Hillman, M.Litt., *Chairman and Director, Center for Information Science*
Thomas Morris Haynes, Ph.D.
Herbert Rubenstein, Ph.D.

Associate Professors

Robert Featherstone Barnes, Ph.D.
Andrew J. Kasarda, Ph.D.
John Ralph Lindgren, Ph.D.
Norman Paul Melchert, Ph.D., *Head, Division of Philosophy*
John J. O'Connor, Ph.D.

Assistant Professors

James S. Green, Ph.D.
John J. Humes, Ph.D.
Nicholas Anthony LaPara, Ph.D.
Louis W. Stern, Ph.D.

Early in the history of Western philosophy, Socrates pointed out that the unexamined life is not worth living. Philosophers of all ages and all traditions have been convinced that men are faced with the continuing challenge of emancipating themselves from the encumbrances of inherited presuppositions. They have taught that men can achieve a disciplined and critical knowledge of their current situation in nature and history.

The aim of the major program in philosophy at Lehigh is to assist the student to acquire the rudiments of this critical capacity, and capacity which will be of considerable value to him whatever career he might decide to pursue at a future date. This aim is implemented by assisting the student to comprehend the nature, scope and relevance of the philosophical enterprise through the courses in the required sequence. Sufficient latitude remains in the optional sequence for pursuing the developing special interests of the student.

Required Preliminary Courses

Phil 14	Introduction to Logic (3)

Required Major Courses

Phil 231	Ancient Philosophy (3)
Phil 235	17th and 18th Century Philosophy (3)
Phil 237	Nineteenth Century Philosophy (3)
Phil 239	Twentieth Century Philosophy (3)

and fifteen additional credits to be selected with the approval of the departmental advisor from other courses in philosophy and other curricula.

Philosophy

Undergraduate Courses

11. Philosophic Problems (3)
A study of the character and relevance of philosophic problems through discussion of contemporary philosophic topics. Sensitivity to the philosophic aspects of everyday issues rather than recall of detailed information will be emphasized. Not open to juniors and seniors. Prerequisite: consent of head of division.

14. Introduction to Logic (3)
An introductory study of the methods used in clear thinking and in the detection of fallacies. Examination of the principles used in testing scientific hypotheses and in the discovery of causes. Illustrations are drawn from the problems of everyday life.

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, 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, Kierkegaard, Feuerbach, Marx, Schopenhauer and Nietzsche. Special emphasis will be given to such issues as social philosophy, the philosophy of history and theory of knowledge.

239. 20th Century Philosophy (3)
A study of major contemporary philosophic movements in the West, including pragmatism, idealism, realism, existentialism, logical positivism, and linguistic analysis. Special emphasis is given to the positions of the various schools regarding the problems of meaning, method, and the philosophic role of scientific knowledge.

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 (2-3)
A course of readings designed primarily for undergraduate philosophy majors. Prerequisite: consent of chairman of department.

272. Readings in Philosophy (2-3)
A course of readings designed primarily for undergraduate philosophy majors. Prerequisite: consent of chairman of department.

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.

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.

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 chairman of department.

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., *Head*
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.
John William Humes, 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 in background, ability, and interests: Systems and Logico-Mathematical.

Systems
The integration of machine and human capabilities and techniques.

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 department 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.

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.

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.

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. 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. (Math. 373, E.E. 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.

402. (Psych. 448) Seminar in Psycholinguistics (3)
Selected topics in psycholinguistics examined in depth and in detail. Prerequisite: I.S. 301.

403. Seminar in Semantic Analysis (3)
Discussion of methods for the componential analysis of the English lexicon and consideration of projection rules for the semantic interpretation of sentences. Prerequisite: I.S. 301. (Offered as required.)

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.

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

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.

Major in Arts and Science College

Designed primarily for students planning professional careers in science, this sequence includes the minimum mathematical and subject matter requirements for entrance to graduate schools. Most students who proceed to graduate school in physics elect, as undergraduates, several additional mathematics, mechanics and physics courses. Graduate schools in medicine, meteorology, geophysics, astrophysics, etc., will usually not require additional physics courses, but will require courses in electronics, biology, geology, astronomy, etc. A student interested in immediate professional employment is advised to study in an engineering curriculum. With specialization and careful planning, a student may embark on some graduate level work in his senior year, or gain an early familiarity with research techniques. Such intensive study will reduce the number of years required for study to the Ph.D. since the courses coordinate with the graduate program in physics.

Required Preliminary Courses

Chem 21,22	Principles of Chemistry (8)
Math 21,22,23	Analytic Geometry and Calculus (12)
Phys 11,12	Introductory Physics I & Lab (5)
Phys 21,22	Introductory Physics II & Lab (5)

Required Major Courses

Phys 32	Introduction to Quantum Mechanics (4)
Phys 90	Electrical Phenomena (1)
Phys 171	Proseminar (1)
Phys 191	Laboratory Techniques (2)
Phys 192	Advanced Laboratory (2)
Phys 212	Electrostatics (3)
Phys 213	Electromagnetism (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)

Majors in College of Engineering

The curriculum in engineering physics is designed to prepare men for careers in scientific work, with emphasis on the applications of science in engineering. The first two years of work are similar to those in the other engineering curricula, and further electives in engineering are recommended. Physics 31 in the fourth semester provides the student with an introduction to quantum mechanics before he begins the intensive intermediate level sequences.

A sequence of courses in theory starting in the fifth semester with Physics 212 and 215 presents mechanics, electricity, and light in a unified modern form. Thermodynamics and statistical mechanics in the senior year completes the intermediate level study of physical theory. Concurrent laboratory courses starting with Physics 90 in the fourth semester give familiarity with research procedures and techniques in vacuum, optics and atomic and nuclear physics, as well as mechanics, electricity and heat. The subject matter courses Physics 362, 363, 364, and 365 comprise a concentrated look at four of the currently most active research areas in physics. Any or all of the latter three can be elected. Election of Physics 369, Quantum Mechanics, is advised for those who will go on to graduate study in physics or in the electrical or aerospace, or materials sciences.

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, elect additional courses in mathematics and physics. Others elect additional work in chemistry, engineering, geophysics, or business, or further studies in the social sciences and the humanities. The latter are equipped for work in business or applied science; they can undertake the solution of problems which have not yet been reduced to engineering practice.

Specialization within the curriculum permits the very capable student to embark on some graduate level work in the senior year, or to gain an early familiarity with research techniques. Such intensive study will reduce the number of years required for study to the Ph.D. since the courses

coordinate with the graduate program in physics.

Freshman Year (See page 44)

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	Electrostatics (3)
Phys 215	Particles and Fields I (3)
Math 322	Methods of Applied Analysis I (3)
	G.S. Requirement (3)
	Electives (3)

Junior Year, Second Semester (17 credit hours)

Phys 254	Optics Laboratory (2)
Phys 213	Electromagnetism (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, and 369.

Undergraduate Courses

3. Heat and Electricity (4)
Introduction to heat, laws of thermodynamics, sound, and steady electric fields and currents. Two lectures, one recitation, and one laboratory period per week. Prerequisites: Math. 23, previously or concurrently; Phys. 1.

4. Electricity, Light, and Atomic Physics (4)
Continuation of Phys. 3. Electromagnetism, induced electromotive forces, electrical fields and currents. Two lectures, one recitation, and one laboratory period per week. Prerequisites: Math. 23, previously or concurrently; Phys. 3.

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.

16. General Physics (3)
A survey of the subject matter of heat, electricity, light and atomic physics for students in the Colleges of Arts and Science and Business Administration. Lecture demonstration and recitations. Prerequisite: Phys. 1.

17. General Physics Laboratory (2)
A laboratory in general physics to accompany Phys. 16. Prerequisite: Phys. 16, preferably concurrently.

21. Introductory Physics II (4)
A continuation of Physics 11. Electrostatics and magnetostatics; A.C. circuits; Maxwell's equations; waves; physical and geometrical optics; quantum physics. Two lectures and two recitations per week. Prerequisites: Physics 11, and Math. 22, 32, or 43 previously or concurrently.

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. 4, preferably concurrently.

100. Industrial Employment
Eight weeks industrial employment during the summer following the junior year, with submission of a written report.

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. 4 or 17.

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. Electrostatics (3)
Principles of electrostatics; Poisson's equation; steady currents and their sources. Prerequisites: Math. 205, Phys. 4, or Phys. 16,17, previously or concurrently.

213. Electromagnetism (3)
A continuation of Phys. 212. Electromagnetic induction; magnetic fields of steady currents; magnetic materials; development of Maxwell's equations; electromagnetic radiation. 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. 4, or Phys. 16, 17 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: Phys. 4 and Math. 23.

254. Optics Laboratory (2)
Optical instruments and techniques. Examination of phenomena, of measuring procedures, and of light sources and recording devices. Prerequisite: Phys. 4.

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, Phys. 4, or Phys. 16, 17 previously or concurrently.

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.

340. Heat, Thermodynamics and Pyrometry (3)
Basic principles of heat, thermodynamics and kinetic theory of gases with emphasis on physical systems.

362. Atomic and Molecular Structure (3)
Structure of atoms and molecules, especially as related to their spectra. Prerequisite: Phys. 62 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 (E.E. 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.

369. Introduction to Quantum Mechanics (3)
Principles of quantum mechanics; applications to atoms and molecules. Prerequisites: Phys. 62, 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 a few fields of physics, with the consequence that several projects are available in each area. Members of the department have particular interest in advanced work in the following areas: experimental and theoretical solid-state physics, experiment and theory in the structure and dynamics of fluids, non-equilibrium statistical mechanics, elementary particle theory and experiment, and nuclear structure theory.

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 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 facilities in the Computer Center, including a CDC 6400 computer.

Current departmental research activities include the following:

Solid State Physics (Experimental). Optical properties of insulators, defects in insulators, electron paramagnetic resonance, and properties of thin films.

Solid State Physics (Theoretical). Energy band calculations in insulators, excited states and lifetimes of defects, properties of impurities in insulators, propagation of stress waves.

Nuclear Theory. The few nucleon problem, properties of light nuclei.

Physics of Fluids. Transition from laminar to turbulent flow in boundary layers, microscopic fluctuations in a flow, shock-induced reactions in gases, energy transfers, relaxations times, lifetimes.

Statistical Physics. Kinetic theory, transport in plasmas with strong magnetic fields, statistical basis of hydrodynamics, non-linear processes.

Elementary Particles (Experimental). Proton-proton scattering, properties of K-mesons, streamer chambers.

Elementary Particles (Theory). Properties of leptons, the vector boson, methods for handling unrenormalized field theories; SU (3) and electromagnetic interactions.

"Laser Physics." Construction of gas lasers and studies of their characteristics; use of gas lasers in determination of oscillator strengths and other atomic parameters; mode structure.

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 mechanics, 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 anistropic 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 emmission. 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 Lionel Brody, Ph.D., *Chairman*
Joseph Maria Brozek, Ph.D.

Associate Professor

George Shortess, Ph.D.

Assistant Professors

Raymond W. Bennett, Ph.D.
Edwin Joseph Kay, Ph.D.
Roger Content Loeb, Ph.D.
William Newman, Ph.D.
Martin L. Richter, Ph.D.

Adjunct Professors

Randall M. Chambers, Ph.D.
James E. Goodson, Ph.D.
Charles M. Morris, Ph.D.
Mervin P. Smolinsky, Ph.D.

The sequence of basic courses in psychology and related sciences is designed to expand the student's understanding of the processes which underlie the complex and varied forms of human and animal behavior, both individual and social. Throughout the required courses, the emphasis is on quantitative and experimental analysis. However, elective courses allow further exploration and deepening of knowledge in special areas of psychological theory and application as well as in many related fields. The relatively small number of required courses makes the major program in psychology particularly well suited for the student who wishes a liberal arts program focused on the natural and social sciences. The nucleus of required courses also forms the foundation for graduate work in any field of psychology, including social psychology, leading to careers in research, college teaching, and a wide variety of applied fields, including clinical, engineering and industrial psychology. In social psychology, the opportunity to augment the psychology major program with electives chosen from social relations should be used. A joint major in psychology and social relations is an increasingly common program of study.

Students interested in medicine, dentistry or law may also profitably choose psychology as their major. Students with these interests would normally augment the major program with courses chosen from other departments related to their career interests. For example, students planning a career in medicine must meet the minimum requirements for admission to medical school which are: 1 year of biology, 1 year of inorganic chemistry, 1 year of organic chemistry, and 1 year of physics.

Required Preliminary Courses

Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Laboratory (1)
Math 41	BMSS Calculus I (3)
Math 42	BMSS Probability (3)
Phil 14	Logic (3)
	or
Phil 261	Introduction to Philosophy of Science (3)
	or
Phil 301	Philosophy of Social Science (3)

Recommended Preliminary Courses

It is strongly recommended that any student considering post-graduate study in psychology take a minimum of 7 semester hours of course work in physical science. This recommendation would normally be met by choosing from Chem. 1, 11; 2, 12; Phys. 1, 16, 17. Additional course work in mathematics, computer programming, and biology is also recommended to be chosen from Math. 43, 44, 334, 105 or Acctg. 111; Biol. 28.

Required Major Courses

Psych 3	Psych as a Natural Science (3)
Psych 4	Psych as a Social Science (3)
Psych 9	Statistical Analysis (3)
Psych 11	General Experimental Psychology (3)
Psych 111	History and Systems (4)
	and two of the following with approval:
Psych 361	Personality (4)
Psych 363	Learning (4)
Psych 364	Sensation and Perception (4)
Psych 365	Physiological Psychology (4)
Psych 367	Experimental Social Psychology (3)
	and two additional courses chosen from department offerings.

For the student who chooses psychology as his major, early in his academic career, there will be extensive opportunities to take free electives throughout the junior and senior years. These electives may be chosen profitably from courses offered in a number of departments other than psychology. Psychology majors are encourged to exercise this choice with the student's interests as the principle guide. A senior comprehensive examination is required.

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 and a general survey of 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 (3)
A survey of basic data and research methods in learning sensation, perception and personality. Laboratory exercises provide direct experience in the application of research methods. Prerequisite: Psych. 3 or 4; Psych. 9, previously or concurrently.

21. (S.R. 21) Social Psychology (3)
For description, see S.R. 21.

106. Motivation (3)
Evaluation of contemporary research and theories of animal and human motivation. Prerequisite: Psych. 3 or 4.

107. Developmental Psychology (3)
Contemporary theories, outstanding research contributions and methods of analysis concerning the sequential and interrelated patterns of physiological and social development. Prerequisite: Psych. 3 or 4.

111. History and Systems (4)
Development of psychology from its roots in the thought of Greek philosophers to the formulation of contemporary systems. Prerequisites: Psych. 3 or 4.

160. Independent Study (1-3)
Readings on topics selected in consultation with a staff member. Research on assigned problems. Supervised field studies. Prerequisites: Psych. 3, 4 and 11 and consent of chairman of department. 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.

292. (S.R. 292) Research Methods (4)
For course description, see S.R. 292.

301. Engineering Psychology (3)
Experimental psychology as applied to the optimal design of machines and tasks. Survey of human capacities and limitations. Introduction to problems of information input, information processing and decision making for the human operator. Prerequisite: Psych. 3 or 4.

302. (S.R. 306) Theories of Personality (3)
A systematic survey of the major theoretical approaches to personality with emphasis on personality as a product of social learning. Critical evaluation of the work of Freud, Adler, Fromm, Horney, Sullivan, Erikson, Lewin, Miller, and Dollard and others. Prerequisite: Three semester hours of psychology or social relations.

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. 3, 4, and 11 or consent of chairman of department.

304. Psychometric Methods (3)
Principles of psychological measurement as related to test construction, psychophysical methods, attitude scales. Prerequisite: Psych. 3, 4, 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, 11.

307. Cognition (3)
Seminar in the processes by which sensory inputs are transformed, reduced, elaborated, stored, recovered and used; includes topics such as 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, 11.

320. (I.S. 302) Psycholinguistics (3)
For course description, see I.S. 302.

322. (S.R. 308) Seminar in Social Psychology (3)
For course description, see S.R. 308.

323. (S.R. 303) Groups and Organizations (3)
For course description, see S.R. 303.

324. (S.R. 304) Human Communication (3)
For course description, see S.R. 304.

361. Personality (4)
Survey of research approaches used to conceptualize personality and to relate personality variables to behavior. An independent research project is required of students in this course. Prerequisites: Psych. 4 and 11.

363. Learning (4)
Basic data and major theories of learning. Laboratory provides an opportunity for repetition of basic experiments using animal and human subjects. Prerequisites: Psych. 3 and 11.

364. Sensation and Perception (4)
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. Laboratory exercises provide an opportunity to apply these methods. Prerequisites: Psych. 3 and 11.

365. Physiological Psychology (4)
The physiological basis for psychological processes. Three hours of class presentation and one laboratory session. Prerequisites: Psych. 3 or 4.

367. (S.R. 301) Experimental Social Psychology (3)
For course description, see S.R. 301.

369. Senior Seminar (3)
Study in depth of selected topics of importance in contemporary psychology. Topics will be selected according to the interests of individual students. Independent study and research are required. Prerequisite: Consent of chairman of department.

370. Senior Seminar (3)
Continuation of Psych. 369. Culminates in presentation of a research paper or scholarly essay. Prerequisite: Consent of chairman of department.

381. Psychological Testing (3)
An introduction to psychometric and projective tests utilized in the appraisal of intelligence, aptitudes, interests and personality with special emphasis on applications in educational situations. Principles of test construction and validation will be stressed. Prerequisites: Psych. 3 or 4, or consent of chairman of department. Open only to graduate students from 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. Prerequisites: Psych. 3 or 4, or consent of the chairman of the department. Open only to graduate students in the School of Education.

For Graduates

The Department of Psychology offers the M.S., Ph.D., and Doctor of Arts. The M.S. and Ph.D. are offered in selected areas of experimental psychology, namely, learning, sensation and perception, and mathematical psychology. Special opportunities for interdisciplinary work exist in sensory psychophysiology, engineering psychology, social psychology, and information sciences. The primary purpose of the program is to educate psychologists for careers in research and college teaching.

The graduate program is designed for students who wish to complete work to the Ph.D. Most students earn the M.S. en route. For all students, successful completion of the program is dependent upon successful performance in research, course work and special examinations, each with equal weight. A low student-faculty ratio, approximately 2:1, makes it possible for all students to establish a close working relationship with the faculty.

Since independent research activity is demanded of the Ph.D. in psychology, the research competence of all students will be continuously evaluated from the first semester. Emphasis throughout is on the ability of the student to initiate research and carry it through all phases of execution to the final written report. From the earliest stages, research effort is directed toward work which is publishable. Required research participation is as follows:

Semester 1. Psych. 426. Research Methods (3). This course is intended to provide an introduction to research activities of the department and culminates in the completion of an independent research project.

Semester 2. Psych. 428. Thesis (3) or Psych. 461 Research.

Semester 3. Psych. 428 (3) or Psych. 429 (3) Thesis.

Semester 4. Psych. 429 (3) or Psych. 461 Research.

All students past the fourth semester, and those entering with the M.S., are expected to engage in doctoral dissertation research or schedule Psych. 461 Research during all semesters remaining. All students are encouraged to do research in topics other than the dissertation area for course credit during the academic year and the summer.

There is no fixed number of course credits required for the Ph.D., although 60 semester hours beyond the B.A. or 30 hours plus a masters degree is typical. Beyond the required participation in research courses noted above, only Psych. 421 and 422, Analysis and Design of Experiments, and Psych. 464, Instrumentation, are required. A selection of courses beyond these is made by the student with the approval of the department chairman. Certain courses are particularly recommended in order to assure broad coverage of basic psychological thought and research. These include: Psych. 432, Perception; Psych. 433, Conditioning and Learning; Psych. 434, Personality; Psych. 435, Social Psychology; Psych. 436, Physiological Psychology; Psych. 437, Psychophysical Measurement; Psych. 438, History of Psychology.

All doctoral candidates will be required to take 12 semester hours of integrated course work relevant to their special interests, in a department other than psychology. Choice of this minor area will be made by the student with the approval of his doctoral committee.

The following special examinations are required of all students. A qualifying examination covering all major areas of psychology with particular emphasis on contemporary

theory and research must be passed in order to qualify for candidacy for the doctoral degree. This examination is given twice a year at the start of each semester. Students entering Lehigh with a B.A. must take this examination not later than the start of their third semester in residence. It is recommended that those students entering Lehigh with an M.S. take the qualifying examination at the start of their second semester in residence. For both groups of students only one re-examination is possible in the event of failure on the first testing.

All students completing a master's thesis will be examined orally on the content of the thesis by the faculty of the department. Departmental approval of the thesis is contingent on successful completion of this examination.

The two remaining examinations are required by the Graduate School. (a) The General Examination is a comprehensive examination in which the student is given the opportunity to demonstrate his overall competence in psychology. This examination is given when required and, normally, is taken one year in advance of completion of the degree requirements. (b) The Final Examination is an oral exam conducted by the Doctoral Committee. While its primary focus is on the dissertation research, it may range over broad aspects of psychology in related fields. There is no formal language requirement. However, for students in some area of specialization the Doctoral Committee may require a demonstration of language competence.

All doctoral candidates must have two semesters of teaching experience. Usually this is accomplished by serving as a teaching assistant in the departmental undergraduate courses. There are also opportunities to serve as a Teaching Intern. This program affords advanced students the opportunity to have supervised teaching experience in other colleges of the area.

The department is located in Williams Hall. This building includes adequate laboratories for individual and group experiments with human subjects. Several research laboratories are reserved exclusively for the use of graduate students. These include a laboratory for visual psychophysics and a laboratory for the study of concept learning. The Bioelectric Laboratory, a privately endowed facility for psychophysiological research with humans and lower animals, is also available for the use of graduate students. Three laboratories used primarily for instructional purposes are equipped with sound and light treated research cubicles which are regularly used by graduate students for individual research projects. Additional facilities within the department include electronic, wood, and metal shops, desk calculators, a library including microfilm copies of commonly used journals, and individual office-study space for graduate students. The University Computer Center, as well as other general purpose facilities, are regularly available for sponsored and unsponsored graduate student research.

The minimum prerequisite for graduate work in psychology is a course in general psychology, a course in experimental psychology including a laboratory and a course in statistics, plus collateral courses in biology, mathematics and the physical sciences. Additional course work, the equivalent of major in psychology, is desirable but not necessary. Promising students with majors in other than psychology or those who lack the full requirements may be accepted with the understanding that deficiencies in the undergraduate program will be added to the minimum graduate program. Normally, applications are reviewed starting on March 1 of the year preceding admission. For those students requesting financial aid it is essential that completed application forms be submitted to the University Office of Admission not later than February 15. In addition to the usual transcripts and letters of recommendations, the department requires that Graduate Record Examination scores in the verbal and quantitative aptitude tests and the advanced test in psychology be submitted.

Financial aid is regularly available in the form of Teaching and Research Assistantships, Graduate Fellowships, and Scholarships. In addition, there are now available a limited number of Teaching Internships as well as NASA Fellowships, NSF Traineeships, and NIMH Traineeships in mathematical psychology.

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.

426. Research Methods (3)
Planning of experiments under both laboratory and industrial conditions. Appraisal of research ideas, methodology, and instrumentation.

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 in learning.

434. (S.R. 422) Personality (3)
Traditional theories of personality will be reexamined in light of current research, particularly in the fields of learning and neurophysiology.

435. (S.R. 423) Social Psychology (3)
Evaluation of contemporary research and theories of group behavior.

436. Physiological Psychology (3)
The study of the anatomical, physiological and biochemical bases of behavior.

437. Psychophysical Measurement (3)
An analysis of theoretical and methodological problems in psychological measurement with particular emphasis on psychological threshold determination and scaling.

438. History of Psychology (3)
Interpretation of selected works of authors who have contributed significantly to the growth of scientific psychology.

448. (I.S. 402) Seminar in Psycholinguistics (3)
For course description, see I.S. 402.

450. Mathematical Models of Learning (3)
Stochastic models of learning; application of game and decision theory to learning.

451. Vision (3)
A systematic study of the methods and chief results in the study of visual processes.

452. (S.R. 402) Theory in Social Psychology (3)
For course description, see S.R. 402.

453. Advanced Topics in Learning (3)
An intensive study of some topic of learning with emphasis on current research, e.g., discrimination learning, avoidance learning, concept learning, problem solving, verbal learning. May be repeated for credit.

454. Theories of Learning (3)
Critical survey of major theories of learning.

455. Topics in Engineering Psychology (3)
Selected topics related to the 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.

456. (S.R. 434) Advanced Social Psychology (3)
Intensive treatment of theory and empirical research in an area of current interest in social psychology.

458. Sensory Psychophysiology (3)
An analysis of the neurological bases of sensation based upon an investigation of receptor mechanisms, afferent processes and central integrative activities.

459. Advanced Topics in Psychophysics (3)
A topic or topics of current interest in psychophysics will be covered intensively, e.g., adaptation level theory, theory of signal detectability, multidimensional scaling. 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)
The seminar will be devoted to the consideration of problems in the preparation and presentation of college courses in psychology. Ancillary problems associated with the profession of psychology will be considered. Practice in teaching. May be repeated for credit.

464. Instrumentation (1)
Demonstrations and practical work covering the basic mechanical, electronic, optical and photographic techniques used in psychological research. An introduction to computer programming will be included. May be repeated for credit.

482. Abnormal Psychology (3)
Principles underlying the major forms of behavior pathology. Prerequisites: Psych. 383. Open only to graduate students specializing in guidance and counseling or reading in the School of Education.

483. Individual Testing (3)
A practicum course on the use of individual tests in the assessment of intelligence and personality. Prerequisites: Psych. 381, 383, and Educ. 473. Open only to graduate students specializing in guidance and counseling or reading in the School of Education.

484. Projective Techniques (3)
Adminstration, scoring and basic interpretive principles of the Rorschach and TAT. Critical examination of these and allied techniques. Prerequisites: Psych. 381, 482 and Educ. 473. Open only to graduate students specializing in guidance and counseling or reading in the School of Education.

486. Theories of Psychotherapy (3)
Review of theoretical formulations underlying the major approaches of psychotherapy. Discussion of principles of therapeutic interviewing, psychoanalysis and group treatment methods. Prerequisites: Psych. 482. Open only to graduate students specializing in guidance and counseling or reading in the School of Education.

Religion

Professor

Arthur Roy Eckhardt, Ph.D., *Chairman*

Chaplain

Hubert L. Flesher, M.A.

15. Phenomenology (3)
Introduction to the field through study of selected data from different religious traditions, using successive methods of interpretation: historical, scientific, theological, and philosophical.

16. Biblical Studies I (3)
Study of Old Testament writings, with emphasis on early religious traditions of the Hebrews; the history of Israel from the founding of the Kingdom through the post-exilic period; social, economic, and political influences on Jewish religion; the prophetic movement; the law; the Temple and its worship; and the importance of Jewish religion for Christianity and for mankind.

17. Biblical Studies II (3)
Study of New Testament writings, with emphasis on the four Gospels, the Acts of the Apostles, and the major Epistles. The life and teachings of Jesus and St. Paul. The theological viewpoint of the primitive Church as reflected in the New Testament.

101. Faiths of the Orient (3)
Study of the rise, development, and teachings of selected major religions of India, China, Japan, and Southeast Asia.

102. Faiths of the West (3)
Study of the rise, development, and teachings of the major religions of Europe and North America with some attention to Islam.

151. The Jewish-Christian Dialogue (3)
Analysis of the confrontation of synagogue and church in history and the present with the aid of current materials on the subject. Stress upon moral issues such as anti-semitism and upon doctrinal similarities and differences between Judaism and Christianity. Some consideration of religious and sociopolitical aspects of the re-establishment of the State of Israel.

211. Recent Theological Trends (3)
Study of major twentieth-century movements in Catholic, Protestant and Jewish thought in the United States and Europe. Among the developments included are liberalism versus conservatism, the demythologization of Scripture, the crisis of technology and secularization, theologies of "the death of God," and the ecumenical movement.

212. Theological Ethics (3)
Study of alternative points of view on the relating of theology and of religious anthropology to practical moral questions. Consideration of the positions of influential theologians and movements respecting marriage, race, politico-economic life, and international affairs. Particular attention to "the new morality" and "situation ethics."

Reserve Officers' Training Corps

Students in the College of Arts and Science and of Business and Economics may substitute advanced Military Science or Aerospace Studies credits for six hours of electives. Students in the College of Engineering may substitute advanced Military Science or Aerospace Studies credits for six hours of general study (elective) courses.

Department of Military Science

Professor

Colonel Ben Louis Wechsler, M.A., *Chairman*

Assistant Professors

Captain Joseph F. Dannenfelser
Captain John S. Ellison, B.S.
Major Donald H. Kunkel
Captain Stephen A. Schmidt, B.S.

Instructors

SSG Robert D. Gaines
MSG Joseph Kress

Assistant

SGM Walter Malich

The general objective of the course of instruction is to produce junior officers who by education, training, attitude and inherent qualities 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 a sense of responsibility. The student's ability to evaluate situations, make decisions, understand people, and practice leadership is 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. The two-year program consists of a six-week basic camp and the two-year Advanced Course. Only students who have demonstrated a potential for becoming effective officers are approved for enrollment in the 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 $102.30 per month. Transportation costs for this camp are paid by the department.

Advanced Courses. The Advanced Course is normally taken in the junior and senior years. Only students who have demonstrated a potential for becoming effective officers are selected for this training. The instruction includes military tactics, logistics, administration, teaching methods, leadership techniques and the exercise of command. Students in this course receive $50.00 per month 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 $106.50 per month plus travel expenses. 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 $50.00 per month for the period that the scholarship is in effect. Scholarships may be awarded for either one, two, three, or four years. 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. The other scholarships are available to outstanding students who are currently enrolled in the four year ROTC program who are completing either their freshman, sophomore, or junior years of college.

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 a Regular Army commission upon graduation.

Flight Training Programs. With an appropriate number of qualified and interested students available, a Flight Training Program may be offered. Flight training is an extracurricular activity conducted by an approved FAA flying school near the University. The instruction consists of 35 hours of ground training and more and 36 hours of flight instruction. 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 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. 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 Aviation Training must serve at least three years on active duty after completing that training.

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. All Military Science credits are credited toward the student's overall cumulative academic average.

Deferment. Students pursuing Military Science courses are eligible to receive deferment from induction under current Selective Service laws and regulations.

Basic Course

13. Basic Military Science (1)
This is an introductory course designed to provide the student with an orientation on the purpose, history and organization of ROTC and the Army. This enables the student to individually evaluate the ROTC program and his military obligation under present laws. The evolution of weapons is discussed with stress on present-day weapons. During leadership laboratory the basic fundamentals of leadership, drill, and exercise of command are presented. One recitation and two hours of leadership laboratory a week.

14. Basic Military Science (1)
During this course the student gains an understanding of the overall picture of Army organization and the magnitude of management responsibilities of key personnel. The integration of these small units into larger teams and the general design of military organization are discussed. The missions and function of units are presented in relation to the roles of the Department of Defense and the other Armed Services. Lastly, the goals, factors, and instruments that influence national power are presented with their implications on the objectives of national security and defense. Leadership laboratory continues individual development with the presentation of the characteristics of military commands and orders, development of command voice, school of the soldier with and without arms, dismounted drill and ceremonies. One recitation and two hours of leadership laboratory a week.

21. Basic Military Science (2)
The course covers the basic principles of map and aerial photography to include use of the compass. An introduction to military tactics and operations is also presented which includes troop leading procedures, organization and composition of basic military teams, and principles of offensive and defensive combat. Leadership laboratory emphasizes the functions, duties, and responsibilities of junior leaders and includes development of leadership potential through practical exercises. Two recitations and two semester hours of leadership laboratory per week.

22. Basic Military Science (2)
This course presents a study of the development of American military institutions, policies, experiences, and traditions in peace and war from colonial times to the present. Emphasis will be on the relationships between the military and other aspects of American society and the role of the military in the preservation and development of the nation. During leadership laboratory, leadership development is continued through practical exercises with students performing in leadership positions. Two recitations and two hours of leadership laboratory per week.

Advanced Course

105. Advanced Military Science (1)
This course initially presents a familiarization with the systems, means, principles and techniques of communications. This is followed by a course on military teaching principles which includes the fundamentals of educational psychology applicable to the five stages of instruction and the techniques used in plannning, presenting and evaluating instruction. During leadership laboratory practical exercises foster the individual's leadership development through emphasis on the duties and responsibilities of junior leaders. Two recitations and two hours of leadership laboratory per week.

106. Advanced Military Science (2)
An analysis is made of the leader's role in directing and coordinating the efforts of individuals and small units in the execution of offensive and defensive combat. The roles of the various branches of the Army are presented. The student will solve case studies in psychological, physiological, and sociological factors which affect human behavior. Also included will be individual and group solutions of leadership problems common to small units. Leadership laboratory continues with practical exercises to develop individual understanding of the duties and responsibilities of junior leaders. Three recitations 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 and Military Science 105 and 106. Completion of the summer camp is a requirement for commissioning. Under certain circumstances approved by the Professor of Military Science this camp may be delayed until after graduation or completion of the Advanced Course.

107. Advanced Military Science (2)
Study is made of combat operations and various military teams. Emphasis is placed in the coordination and planning necessary between the elements of the team. Also included are studies of the value and basic concepts of military intelligence, staff organization and functions, and logistics. Leadership laboratory fosters leadership positions in the cadet corps which affords practical experience in planning and executing practical exercises and actual instruction to junior cadets. Three recitations and two hours of leadership per week.

108. Advanced Military Science (1)
An analysis is made of selected leadership amd management problems involved in unit administration and military justice. The position of the United States in the contemporary world scene is discussed. An orientation is conducted on the obligations, problems and responsibilities of an officer entering on active duty. Leadership laboratory continues as an extension of the first semester's program. Two recitations and two hours of leadership laboratory each week.

Note: Two four-hour leadership laboratories will be conducted on Saturday afternoons during each semester. Attendance at these sessions will eliminate the requirement for at least the equivalent number of the regular two-hour weekly sessions during winter months.

Department of Aerospace Studies

Professor

Lieutenant Colonel Glenn F. Stauffer, Ph.D., *Chairman*

Assistant Professors

Major Richard C. Brace, M.S.
Captain Delford G. Britton, M.A.
Major Joseph C. Surico, M.A.

Assistants

Staff Sergeant Jesse Marsh
Staff Sergeant Donald Podoll
Staff Sergeant Carl. L. Young, Jr.

The Lehigh Unit of the Air Force Reserve Officer Training Corps was established in October 1946. Its program is designed to prepare students for commissions in the United States Air Force upon successful completion of an undergraduate course. The Department of Aerospace Studies offers two programs for students to qualify for commission: one of four years and one of two years. Any student who has met or will meet the baccalaureate degree requirements at the end of his university education may apply for entrance into the four or two year program. He must complete his AFROTC training and university education and be commissioned by his 28th birthday.

Four-Year Program. The four year program consists of classroom and laboratory work during the four undergraduate years and one field training period of four weeks, usually between the junior and senior years, at a United States Air Force base.

During the first two years the program acquaints students with military and aerospace technological advances and current research and development activities. Leadership training is also begun. During the last two years, emphasis is placed on personal development. Students increase their leadership ability by assuming positions of responsibility in the Cadet Corps. To insure that they will keep abreast of the developments in the Air Force, students continue to receive information on technological changes.

While in an undergraduate status, Air Force ROTC students are furnished, free of charge, all text and reference books, uniforms, and equipment required for aerospace study. Under the provisions of the Reserve Officers Training Corps Revitalization Act of 1964, Air Force ROTC Cadets who are members of the four-year program are offered an opportunity to compete, on a nationwide basis, for full college scholarships which include tuition, fees and books, plus a retainer of $50 per month. Those fully enrolled cadets who do not obtain a financial assistance grant will receive $50 monthly during their junior and senior years.

At the beginning of the junior year, or upon initiation of a college scholarship, each student is required to sign a formal

agreement that he will complete the Professional Officer Course and accept a commission as a second lieutenant in the United States Air Force when he has been granted his degree. Also, the student is sworn into the Enlisted Reserve of the United States Air Force. The term of commitment after commissioning for any non-flying professional area is four years. If the student is physically qualified and desires to become a pilot or navigator, the required term of service is five years, after completion of flying training.

Two-Year Program. The two-year program is for those students who are unable to complete the first two years of the four-year Air Force ROTC program. Such students may apply during their sophomore year for acceptance into the two-year program. In lieu of completing the freshman and sophomore years of the four-year program and the four-week summer training, these men will receive field training in a six-weeks' officer training course conducted on an Air Force base during the summer between the sophomore and junior years. Upon successful completion of the six-week intensive military and academic program, they will return to the campus to be enrolled in the Professional Officer Training Course to complete the same academic program required of the four-year students. These students receive $50 a month in subsistence allowance. This program is also available to selected graduate students, on a limited basis, who have two full years of academic study remaining at Lehigh University.

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.

General Information on Both Programs. Adjustment in the Aerospace program will be made to accommodate students enrolling in an honors or cooperative course. Students who are eligible for and desire graduate education immediately after completing their undergraduate work may request a delay in reporting for active duty until completing their graduate degree.

Eligibility Requirements. To be eligible for the Air Force ROTC program a student must be: (1) a male 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, which obligates him to remain in the ROTC program, to accept a commission, and to serve the required period in the Air Force upon graduation.

General Military Course

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; review of Army, Navy and Marine general purpose forces.

23. Sophomore Aerospace Studies (1)
A study of defense policies; theories of general war; the nature and context of limited war; the policies and strategies of the Soviet Union and China; and the role of alliances in U.S. defense policies.

24. Sophomore Aerospace Studies (1)
A study of defense organization and decision-making; the organization and function of the Department of Defense; the role of the military in the United States' national policies; the elements and process of defense decision-making.

Professional Officer Course

111. Aerospace Studies—Air Force Officer Development (3)
Development of the knowledge and skills required of the junior officer in the Air Force. This will include the nature of war, history of air power, and the mission, doctrine, and employment of the United States Air Force.

112. Aerospace Studies—Air Force Officer Development (3)
Continuation of the development of knowledge and skills required of a junior Air Force Officer. This will include the history and importance of 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)
Introduction to military professionalism. 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)
A military explanation of leadership and management. Includes principles and functions of management, Air Force personnel policies, channels of communication, problem solving, the command-staff team, the subordinate, performance standards, data processing, and Air Force controls.

Romance Languages & Literatures

Professors

John Andrews Van Eerde, Ph.D., *Chairman*
Victor Manual Valenzuela, Ph.D.

Assistant Professors

Biruta Cap, Ph.D.
Anje C. Van Der Naald, Ph.D.

Visiting Instructor

Gombilenga Mikongomi, Cert.

Instructors

Walter F. Marshall, M.A.
Alberto Romero, Licentiatus, M.A.

The department of Romance Languages offers separate major programs in French and Spanish aiming to show the development of the culture and civilization of France, Spain, and the Spanish-speaking countries of Latin America. These programs prepare for graduate work in several related fields as well as for teaching careers.

Each candidate is assigned a departmental advisor to correlate and integrate supplementary reading and study to meet special objectives. Candidates are urged to participate in junior-year-abroad programs and in study and travel in foreign countries during summer vacations.

Although the minimum requirement is eighteen credit hours of which at least six will be chosen from "200" courses, the normal requirement consists of eight semester courses above 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 oral and written departmental comprehensives and the graduate record examinations.

French

Required Preliminary Courses

Fr 1, 2	Elementary French (6)
Fr 3, 4	Elementary French (10)
Fr 11, 12	Intermediate French (6)
Fr 13, 14	Intermediate 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 41, 42	French Oral and Written Composition (6)
Fr 51, 52	Types of French Literature (6)
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 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)

Undergraduate Courses

1. Elementary French (3)
Basic conversational French illustrating essential grammatical principles. Emphasis on aural-oral learning with required laboratory practice.

2. Elementary French (3)
Continuation of Fr. 1, with the addition of simple vocabulary-building tests. Prerequisite: Fr. 1.

3. Elementary French (5)
Basic conversational French illustrating essential grammatical principles, reading of simple texts and writing; some laboratory.

4. Elementary French (5)
A continuation of French 3. Prerequisite: French 3, or Achievement Test score before entrance, or consent of chairman of department.

11. Intermediate French (3)
Reading based on works of the nineteenth and twentieth century writers; formal review of French grammar; prose composition; outside reading. Prerequisite: one year of college French or two units of entrance French.

12. Intermediate French (3)
Continuation of Fr. 11. Prerequisite: Fr. 11.

13. Intermediate 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. Intermediate French (3)
Emphasis on readings and discussion. Prerequisite: Fr. 3, or Achievement Test score before entrance, or consent of chairman of department.

41. 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. 12, or 3 units of entrance French, or consent of chairman of department.

42. French Oral and Written Composition (3)
Continuation of Fr. 42. Prerequisite: Fr. 41, or consent of chairman of department.

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.

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 dramatist 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 "Enclyclopedistes" 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 reading 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 French 321. French 322 cannot count as a language course. Prerequisite: Fr. 321, or consent of chairman of department.

381. French Cultural Program (3-6)
A summer program in France offering formal language courses and cultural opportunities to teachers of French.

411. Voltaire (3)
Representative 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.

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.

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.

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.

Spanish

Required Preliminary Courses

Span 1, 2	Elementary Spanish (6)
Span 3, 4	Elementary Spanish (10)
Span 11, 12	Intermediate Spanish (6)
Span 13, 14	Intermediate Spanish (7)

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 31, 32	Spanish Conversation and Composition (6)
Span 51	Cultural Evolution of Spain (3)
Span 52	Cultural Evolution of Latin America (3)
Span 53	Introduction to Modern Spanish Fiction (3)
Span 54	Introduction to Modern Spanish Drama (3)
Span 271, 272	Readings (6)
Span 303	Cervantes (3)
Span 305	Spanish Literature in the Middle Ages (3)
Span 306	Spanish 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 331, 332	Spanish-American Literature (6)

Undergraduate Courses

1. Elementary Spanish (3)
Basic conversational Spanish illustrating essential grammatical principles. Emphasis on aural-oral learning with required laboratory practice.

2. Elementary Spanish
Continuation of Span. 1, with addition of the use of simple vocabulary-building and reading texts. Prerequisite: Span. 1.

3. Elementary Spanish (5)
Basic conversational Spanish illustrating essential grammatical principles, reading of simple texts and writing; some laboratory.

4. Elementary Spanish (5)
A continuation of Span. 3. Prerequisite: Span. 3, or Achievement Test score before entrance, or consent of chairman of department.

11. Intermediate Spanish (3)
Reading of modern Spanish prose, with a view to acquiring exactness and speed in reading; rapid review of grammar, composition, and conversation. Prerequisite: one year of college Spanish or two units of entrance Spanish.

12. Intermediate Spanish (3)
Continuation of Span. 11. Prerequisite: Span. 11.

13. Intermediate Spanish (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: Span. 4, or Achievement Test score before entrance, or consent of chairman of department.

14. Intermediate Spanish (3)
Emphasis on readings and discussion. Prerequisite: Span. 13, or Achievement Test score before entrance, or consent of chairman of department.

31. Spanish Conversation and Composition (3)
For students who wish a greater opportunity for practice in the oral and written use of Spanish than can be provided in the literature courses. Special attention given to the history and culture of Spain. Conducted in Spanish. Prerequisite: two years of college Spanish or three units of entrance Spanish.

32. Spanish Conversation and Composition (3)
Continuation of Span. 31, with special attention given to Latin-America area studies. Conducted in Spanish. Prerequisite: Span. 31.

51. Cultural Evolution of Spain (3)
The historical and cultural evolution of Spain from its beginning to the present. Reading of representative Spanish authors. A term paper in Spanish is required. Prerequisite: Span. 12 or four units of entrance Spanish, or consent of chairman of department.

52. Cultural Evolution of Latin-America (3)
Continuation of Span. 51. The historical and cultural evolution of Latin America. Reading of representative Latin-American authors. A term paper in Spanish is required. Conducted in Spanish. Prerequisite: Span. 51 or consent of chairman of department.

53. Introduction to Spanish Fiction (3)
Readings and discussion of selected novels and short stories; outside reading and reports. Conducted in Spanish. Prerequisites: Span. 51-52 or five units of entrance Spanish, or consent of chairman of department.

54. Introduction to Spanish Drama (3)
Reading and discussion of selected plays; outside reading and reports. Prerequisite: Span. 53, or consent of chairman of department.

For Advanced Undergraduates and Graduates

A student wishing to qualify for a master's degree in Modern Foreign Languages and Literatures should have an undergraduate major or its equivalent in Spanish. 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. The candidate may concentrate in Peninsular or Latin American Literature, or he may combine both. 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 groups of authors, or of a period. Prerequisite: Span. 51-52 or Span. 53-54 or consent of chairman of department.

272. Readings (3)
Continuation of Span. 271. Prerequisite: Span. 51-52 or consent of chairman of department.

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: Span. 53-54 or consent of chairman of department.

302. The Latin-America 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: Span. 53-54 or consent of chairman of department.

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. 53-54 or consent of chairman of department.

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. 53-54 or consent of chairman of department.

306. Latin America Literature Since World War II (3)
Reading and discussion of representative works of contemporary Latin-American authors. Given in Spanish. Prerequisite: Span. 53-54 or consent of chairman of department.

307. The Golden Age (3)
A study of the representative works. Conducted in Spanish. Prerequisite: Span. 53-54 or consent of chairman of department.

308. Spanish Literature Since the Civil War (3)
Reading and discussion of representative contemporary Spanish authors such as Cela, Matute, and Sender. Collateral reading and reports. Conducted in Spanish. Prerequisites: Span. 53-54 or consent of chairman of department.

309. Sixteenth Century (3)
Representative readings. Conducted in Spanish. Prerequisite: Span. 53-54 or consent of chairman of department.

310. Nineteenth Century Spanish Novel (3)
Representative works. Conducted in Spanish. Prerequisite: Span. 53-54 or consent of chairman of department.

321. Latin American Literature in Translation (3)
Reading and discussion of outstanding works of Latin American literature in translation to provide insight into Latin America culture. No knowledge of Spanish is required. Span. 321 cannot count as a language course. Prerequisite: a college course in literature or consent of chairman of department.

322. Latin American Literature in Translation (3)
A continuation of Span. 321. Span. 322 cannot count as a language course. Prerequisite: Span. 321 or consent of chairman of department.

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 53-54 or consent of chairman of department.

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 53-54 or consent of chairman of department.

397. Spanish Cultural Program (3-6)
A summer program abroad. Includes formal instruction on the Spanish language as well as direct contact with the Spanish people and their culture during two months in Spain.

398. Spanish Cultural Program (3-6)
A summer program in Spain offering formal language courses and cultural opportunities to teachers of Spanish.

411. Twentieth Century Spanish Theatre (3)
A study of the representative plays. Conducted in Spanish. Prerequisite: a 300-level course or equivalent, or consent of chairman of department.

412. Neruda and Mistral (3)
A study of the representative works of these authors. Conducted in Spanish. Prerequisite: a 300-level course or equivalent or consent of chairman of department.

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 equivalent or consent of chairman of department.

414. Twentieth Century Spanish Poetry before the Civil War (3)
Representative readings. Conducted in Spanish. Prerequisite: a 300-level course or equivalent or consent of chairman of department.

416. Lope De Vega (3)
The development of the Spanish Drama of the Golden Age, including the important plays of Lope De Vega. Collateral reading and reports. Given in Spanish. Prerequisite: a 300-level course or equivalent or consent of chairman of department.

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 Kiswahlili readings, and a short survey of 18th and 19th century Kiswahili literature. Prerequisite: Ksw. 11 or consent of the chairman of the department.

Social Relations

Professor

Robert Clifford Williamson, Ph.D., *Chairman*

Associate Professors

Robert Griffith Jones, Ph.D.
Leo F. Van Hoey, Ph.D.
Roy Cecil Herrenkohl, Jr., Ph.D.

Assistant Professors

James Rathburn McIntosh, Ph.D.
Betty Potash, Ph.D.

Lecturer

David C. Amidon, Jr., M.A.

Visiting Instructor

Joanne K. LoGuidice, M.S.

There are three major sequences combined in the department of Social Relations: social psychology, sociology, and anthropology—behavioral sciences. Students majoring in the department 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, 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)
Psych 3 or 4	Introduction to Psychology (3)
Math 41	BMSS Calculus I
	or
Phil 14	Introduction to Logic (3)
	Nine hours of the following:
SR 11	Principles of Sociology (3)
SR 21	Social Psychology (3)
SR 31	Cultural Anthropology (3)

Recommended Courses

Eco 1	Economics (4)
Hist 331	The Negro In America
	or
Hist 333	American Urban History to 1880
	or
Hist 334	American Urban History, 1880 to Present (3)
IS 301	Descriptive Linguistics
	or
IS 302	Psycholinguistics (3)
Phil 14	Logic (3)
Math 42	BMSS Probability (3)
Math 105	Computer Programming (3)
Psych 9	Statistical Analysis (3)

Option in Social Psychology

	Twelve hours of the following:
SR 301	Experimental Social Psychology (3)
SR 303	The Social Psychology of Groups (3)
SR 304	Human Communication (3)
SR 308	Seminar in Social Psychology (3)
SR 306	Theories of Personality (3)
	and
Psych	Approved Courses (6)
SR	300 level courses, in anthropology or sociology (6)

Option in Sociology

	Fifteen hours from 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)
	Approved Electives (3)
SR	300-level courses in anthropology or social psychology (6)

Option in Anthropology-Behavioral Sciences

Twenty-four hours of which at least twelve will be chosen from SR 332, 333, 335, 336, 339, 394, and IS 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. Not open to students who have had or are taking S.R. 11, 21, or 31.

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. Not open to students who have taken or are taking S.R. 11, 21, or 31.

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, socializations, stratification, social institutions, ethnic relations, social change. Not open to students who have had or are taking S.R. 3 or 4.

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. Not open to students who have had or are taking S.R. 3 or 4.

31. Cultural Anthropology (3)
Examination of the scope, aims and methods of anthropology; the nature of culture; the cultural evolution of man; the range of culture phenomena emphasizing economic organization, kinship and social organization, political organization, and religion; and a brief introduction to the history of ethnological theory. Analysis of the characteristic features of the life, thought, and culture of selected primitive and peasant peoples throughout the world. Not open to students who have had or are taking S.R. 3 or 4.

55. Primitive Peoples (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.

65. Contemporary Social Problems (3)
An exploration of major problems facing contemporary men, 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 of intergroup cooperation and conflict.

For Advanced Undergraduates and Graduates

220. (U.S. 220) Urban Elites (3)
Emergence, characteristics and functions of elites in urban-industrial society. Recruitment, displacement and decay of elites. Various models of elite structure.

292. (Psych. 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.

301. (Psych. 367) Experimental Social Psychology (3)
Training in design, execution and interpretation of experiments in social psychology. An opportunity for original research. Prerequisite: six credit hours in Social Relations or consent of chairman of department.

303. (Psych. 323) 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. (Psych. 324) 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.

306. (Psych. 302) Theories of Personality (3)
For course description, see Psych. 302.

308. (Psych. 322) Seminar in Social Psychology (3)
Intensive consideration of selected topics in current theory and research in social psychology. The subject matter will vary from semester to semester, and will include such topics as the social psychology of education, the applications of perception and learning theory to social psychological problems, the social psychology of science, and the social environment of communication. Prerequisite: S.R. 21 or consent of chairman of department. May be repeated for credit.

320. (U.S. 320) Urban Ethnology (3)
Ethnocultural groups in urban settings. Patterns of conflict, accomodation and assimilation studied with particular reference to the United States.

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.

333. Primitive Political Systems (3)
A comparative analysis of systems of law, government, and politics among selected tribal and peasant societies. Analysis of the sources and functions of law and government in particular societies, examination of systems of social control, and the conflict of these cultural systems in the modern world. Attention to historical contemporary anthropological theory in this area. Prerequisite: six credit hours in Social Relations 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. Prerequisite: six credit hours in Social Relations or consent of chairman of department.

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. Prerequisite: six credit hours in Social Relations or consent of chairman of department.

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.

360. Social Change in Africa (3)
An examination of the basic structures of traditional society and of the processes of social organizations originating in the colonial era and continuing into the evolving system of new nations of Africa.

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. Prerequisite: six credit hours in Social Relations or consent of the chairman of the department.

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 family, education, 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 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 considerd 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

402. (Psych. 452) Theory in Social Psychology (3)
A critical analysis of theoretical orientations in social psychology, their place and relevance to the scientific study of human interaction. Behavioristic, phenomenological and mathematical theories will be compared and evaluated.

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.

422. (Psych. 434) Personality (3)
For course description, see Psych. 434.

423. (Psych. 435) Social Psychology (3)
For description, see Psych. 435.

432. Culture Patterns and Personality (3)
The psychological implications of cultural variation, including the analysis of national character.

434. (Psych. 456) Advanced Social Psychology (3)
For description, see Psych. 456.

437. Anthropological Theory (3)
An examination of the theoretical foci of anthropology and its relation to disciplines, e.g., ecology, linguistics, ethno-history, the cross-cultural study of cognition, etc.

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.

Division of Urban Studies

Associate Professors

Leo F. Van Hoey, Ph.D., *Head*
Joseph Logsdon, Ph.D.
Leonard I. Ruchelman, Ph.D.

Assistant Professors

Stephen D. Bryen, Ph.D.
James R. McIntosh, Ph.D.

Instructors

David C. Amidon, Jr., M.A.
Roger D. Simon, M.A.

Students who wish to concentrate on urbanization and related problems of analysis and planning may apply for the interdisciplinary option in Urban Studies within existing majors. The enrollment is open to students from every background and discipline. Applications are made from within departments. Course schedules are worked out with the advice of the faculty members who actively participate in the division with the agreement of the student's major advisor in the department. Schedules are flexible beyond the requirements of the departments and the core curriculum leading to the major in Urban Studies.

Required Preliminary Courses

Determined by the student's discipline in his department.

Major (Option Urban Studies) Required Sequence (minimum 18 credit hours)

US 21	Emerging Cities (3)
US 31	The Study of Urbanization (3)
US 311	Urban Process (3)
US 312	Urban Inquiry (3)
	at least one course from the following group:
FA 51	Urban Design (3)
Eco 212	Urban Economics (3)
Hist 333	American Urban History to 1880 (3)
Hist 334	American Urban History, 1880 to Present (3)
	and at least one course from the following group:
SR 320	Urban Ethnology (3)
SR 368	Urban Communities (3)
Govt 357	Urban Politics (3)
Govt 358	Community and Regional Politics (3)

Recommended courses suggested by advisors will depend on the student's personal interests and stated vocational orientation.

Final requirements for seniors allow for two options: (1) a comprehensive examination, or (2) a report of substantive research conducted by the student, the decision in favor of one or the other being worked out by the student and his advisor(s), subject to the approval of the head of the division.

Undergraduate Courses

21. Emerging Cities (3)
A consideration of classic and modern views of the city from antiquity to the present. Discussion of contemporary urban conditions.

31. The Study of Urbanization (3)
An appraisal of the study of urbanization comparing the different perspectives, concepts and methods of sociology, anthropology, political science, history, geography and economics. Prerequisite: U.S. 21.

51. (F.A. 51) Urban Design (3)
The influence of design and planning professions on the form and function of cities. Analysis of the theoretical and actual roots of current concepts of planning and design, with special reference to the means and methods of programming, design, construction and evaluation of such urban scale projects as public housing, mass transit networks, cultural centers and satellite towns. Prerequisite: consent of chairman of Fine Arts department.

For Advanced Undergraduates and Graduates

212. (Eco. 212) 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. Prerequisites: Eco. 3 and 4 or consent of instructor.

220. (S.R. 220) Urban Elites (3)
For course description, see S.R. 220.

311. Urban Process (3)
A comparative analysis of emergence, differentiation and limits of urbanization under varying social and technical conditions, with special emphasis on the spatial coordinates of the evolving economic, political and associational frameworks of societies in the course of expanding scale of social organization. Prerequisites: U.S. 21 and 31.

312. Urban Inquiry (3)
Examination of basic research methods pertaining to different areas of investigation in the context of urban structures and urban processes. Particular emphasis on the practice of research and the execution of individual study designs. Prerequisites: U.S. 21, 31, and 311.

320. (S.R. 320) Urban Ethnology (3)
Ethno-cultural groups in urban settings. Patterns of conflict, accomodation and assimilation studied with particular reference to the United States.

333. (Hist. 333) American Urban History to 1880 (3)
The city in American history from colonial times to 1880. Colonial maritime centers, New York's rise to pre-eminence, urban imperialism and regional rivalries, changing transportation patterns and diffusion of urban sites, and early industrial cities. Prerequisite: consent of the chairman of the department of history.

334. (Hist. 334) American Urban History, 1880 to Present (3)
The city in American history since 1880. Industrialization and urban social structure, new urban technology, "reformers" vs. "bosses," social welfare and social control, suburbanization, declining localism and the rise of an urban mass society. Prerequisite: consent of the chairman of the department.

357. (Govt. 357) 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 politics of municipal reform; city planning and urban renewal.

358. (Govt. 368) Community and Regional Politics (3)
Analysis of the changing political dimensions of community in the context of regionalism. Attention directed to "the metropolitan problem."

368. (S.R. 368) Urban Communities (3)
A study of urban communities in the world and in the United States. 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 the department of Social Relations.

371. Special Topics in Urban Studies (1-3)
Advanced work through supervised reading and research. Prerequisite: consent of head of division.

372. Special Topics in Urban Studies (1-3)
Continuation of U.S. 371. Second semester.

For Graduates

The Urban Studies Program (U.S.P.) is an interdisciplinary graduate program leading to the master's degree in social science disciplines with a stated emphasis on problems of research and planning related to urbanization.

The objectives of the program are: (1) the coordination of the scholarly activities which focus on urbanization in the various schools and departments of the University; (2) the creation of a proper environment where students from different backgrounds have the opportunity of expanding urban inquiry across disciplinary lines in order to achieve efficiency in dealing with the social and the technical intricacy of urban problems; (3) the promotion of policy-relevant research and studies of interdisciplinary scope in order to bridge the gap between basic research and the practical use of knowledge in the community; (4) the furthering of a variety of callings, e.g., careers in urban research and planning organizations, careers in public and private institutions connected with community programs, services and administration, or careers in educational institutions, community colleges and junior colleges. The program will also serve students who wish to pursue specialized studies on the Ph.D. level in this institution or elsewhere.

Graduate students work from within the disciplines of their choice toward a master's degree with the Urban concentration in that field. They must therefore fulfill the entrance requirements of the chosen department and have at least nine hours of undergraduate work bearing on urban studies, or otherwise satisfy the head of the U.S. program that they are qualified to pursue this line of studies. All students are required to take U.S. 415 and 416.

415. Research in Urban Areas (3)
The application of participant observation, survey research and other methods to problems and processes in the urban setting. Particular emphasis on the exploration and the testing of contemporary generalizations concerning urban problems. Prerequisite: consent of instructor.

416. Advanced Urban Seminar (3)
The intensive pursuit of particular questions and problems of urban inquiry focused on selected topics of research and planning designs in the United States. Prerequisite: U.S. 415 and consent of the head of the Urban Program.

Curricula

Beyond these two courses (6 credit hours) the schedules are defined by the respective departments.

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	Micro-Economics (3)
Eco 436	Macro-Economics (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 461	Community Power Structure (3)
Govt 462	Metropolitan Politics (3)

A comprehensive examination (general economics, urban inquiry) is required.

Government, advisor: Messrs. Colon and Ruchelman (30 credit hours)

Govt. 460	Community Power Structure
	or
Govt 461	Metropolitan Politics (3)
Govt 357	Urban Government
	or
Govt 358	Community and Regional Politics (3)
Govt	additional courses (12)
	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)
Hist 442	Readings in United States History (3)
SR 468	Advanced Urban Sociology (3)
SR 472	Special Topics (3)

A comprehensive examination (theory, urban inquiry, option) is required.

History, advisor: Mr. Logsdon (33 credit hours)

Hist 401	Methods in Historical Research (3)
Hist 440	Any Course, including 442 when urban topic offered (9)
Hist 450	Any Course, including 452 when urban topic offered (6)
	and one course from the following:
SR 468	Advanced Urban Sociology (3)
Govt 461	Community Power Structure (3)
Govt 462	Metropolitan Politics
	or
Eco 440	Regional Science—Metropolitan Analysis (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:
Govt 461	Community Power Structure (3)
Govt 462	Metropolitan Politics (3)
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)
Hist 442	Readings in United States History (3)
	Thesis (6)

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.S.
B. Thayer Turner, B.S.

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Charles R. McNaron, B.S.
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Stanley R. Schultz, B.A.
Thomas D. Shreiner, B.S.
John Calvin Whitehead, B.S.

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 emphasizes 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, the field house, 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 410 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 and Intramural Sports

The department of Physical Education and Intramural Sports has supervision and control of the recreational physical activities of the student body. The aim of the department 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 form 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 physical fitness test for the purpose of guidance and counseling in the voluntary program of personal development, and all are required to take a swimming test. Both tests are scheduled during the first week of the first semester. Each undergraduate should be able to swim 75 feet before graduation. Based on the results of the tests, each student is urged to follow the recommendations of counsellors 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 a four-week attendance 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, physical development, boxing, fencing, apparatus exercises, life-saving, controlled weight training, badminton, 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, 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.

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Partner
McFadden, Riskin and Huston, Bethlehem

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Dean, College of Engineering

John A. Stoops, Ed.D.
Dean, School of Education

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Dean, Graduate School

Brian George Brockway, LL.M.
Dean, College of Business and Economics

Willard Ross Yates, 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.
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Assistant Dean, College of Business and Economics

Norman Harold Sam, Ed.D.
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James Harold Wagner, M.A.
Secretary to the Faculty

Student Personnel Services

Charles Wilfrid Brennan, M.B.A.
Dean of Students

Clarence Bowen Campbell, M.A.
Dean of Residence

Arthur Howard Mann, S.T.B.
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William Leroy Quay, Ph.D.
Dean of Student Life

Nathan W. Harris, B.S.
Assistant Dean of Student Life

Ruth A. Hurley, M.S.
Associate Dean of Student Life

Joseph H. Reynolds, A.B.
Assistant to the Dean of Student Life

Barbara Elizabeth Solt, M.S.S.W.
Coordinator, Volunteer Community Services

Robert Peter Shurtleff, M.Ed.
Assistant Dean of Residence

Evelyn Strawn Eberman, B.A.
Assistant to the Dean of Residence

James A. Tiefenbrunn, B.S.
Assistant to the Dean of Residence

Business Offices

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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
Assistant Accountant

Bruce A. Wagaman, B.S.
Assistant Accountant

Robert Warren Numbers, B.S. in C.E.
Superintendent, Buildings and Grounds

Kenneth E. Orben, B.S. in E.E.
Assistant Superintendent, Buildings and Grounds

Paul Theodore Miller
Assistant Superintendent, Buildings and Grounds

Frank S. Donchez
Captain of Police

Robert W. Bell, M.S.
Director, Book Store

Stanley Frederick Heffner
Manager, Book Store

Kenneth M. Trumbore, B.A.
Assistant Manager, Book Store

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Registrar

Frederick Eugene Ressler, A.B.
Associate Registrar

Rodney Earl Ressler
Assistant Registrar

Leanor Ruth Gilbert
Recorder

Claire C. Biser
Assistant to the Registrar

Office of Development

Robert Mark Holcombe, M.S.
Director of Development

Michael G. Bolton, M.B.A.
Associate Director of Development, and Director of Corporate and Foundation Resources

Charles Keller Zug, B.S.
Advisor, Bequests, Trusts and Insurance

Austin V. McClain, M.A.
Consultant

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Director

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Samuel Irvin Connor, B.A.
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Diane Kay Shaffer, B.S.
Assistant to the Director

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James Willard McGeady, B.A.
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Robert F. Reeves, B.A.
Assistant to the Director

Office of Undergraduate Financial Aid

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Director

Deborah J. Dwyer, B.S.
Assistant to the Director

Alumni Association

James W. Niemeyer, B.S.
Executive Secretary

Harry Bohlin Ramsey, B.A.
Assistant Executive Secretary, Editor Lehigh Alumni Bulletin

Fred Assenheimer, B.A.
Assistant Executive Secretary

Lucile Barrett, A.B.
Assistant to the Editor, Lehigh 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, 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 Catalogers

Lynne Carol Marsh, A.M.L.S.
Social Science Cataloger

Caroline Gladys Cochrane, M.L.S.
Science Cataloger

Linda Ann Myers, M.L.S.
Humanities Cataloger

Sharon Lois Matley, M.L.S.
Reference Librarian, Mart Library

Kenneth J. Veprek, M.S.L.S.
Reference Librarian, Mart Library

Olive Stengle
Circulation Supervisor

Robert E. Reidnauer
Automation Assistant

Packer Memorial Chapel

The Rev. Hubert L. Flesher, M.A.
Chaplain

Robert Benjamin Cutler, M.A.
Organist

University Placement and Personnel Services

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Edward J. Trost, M.A.
Assistant to the Director

Helen Z. Rayner
Administrative Assistant

University Counseling Services

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Director

Robert Roupen Panos, Ph.D.
Assistant Director

William Joseph Sibley, M.Ed.
Counselor

Mildred J. Crosby
Psychometrician

University Health Service

Howard C. Pieper, M.D.
Director

George Walter McCoy, Jr., M.D.
Consulting Physician

Duane E. Stackhouse, M.D.
Associate Director

P. Lawrence Kreider, 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

James B. Goyne, M.D.
Consulting Psychiatrist

Division of Athletics and Physical Education

William Bader Leckonby, B.S.
Director

John Stohler Steckbeck, M.S.
Assistant Director of Physical Education

Gerald Grant Leeman, B.A.
Assistant to the Director of Physical Education

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Director, and Assistant Director of Administrative Services

Wayne Hoffman
Systems Analyst

William J. McGarry, M.B.A.
Systems Analyst

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.
Assistant Director

Mary Jo Hill, M.A.
Editorial Associate

Computing Center

John E. Smith, M.A.
Director

John E. Walker, Ph.D.
Manager, User Applications

William F. Hollabaugh, Ph.D.
Systems Group Leader

William E. Schiesser, Ph.D.
Technical Associate

Robert A. Pfenning
Manager, Software Distribution

Maurice Jones
Manager, Computing Associate Program

Joseph P. Holzer
Administrative Assistant

Charles J. Cheddar
Analyst

Judy Schleicher
Senior Programmer

David March, M.Ed.
Senior Systems Analyst

Robert L. Pettigrew, B.S.
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Materials Research Center

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Sidney R. Butler, Ph.D.
Director, Advanced Materials Laboratory

Richard Warren Hertzberg, Ph.D.
Director, Mechanical Behavior Laboratory

John Alexander Manson, Ph.D.
Director, Polymer Laboratory

Michael R. Notis, Ph.D.
Advanced Materials Laboratory

Walter E. Dahlke, Ph.D.
Advanced Materials Laboratory

Frank J. Feigl, Ph.D.
Advanced Materials Laboratory

R. Wayne Kraft, Ph.D.
Advanced Materials Laboratory

Leslie H. Sperling, Ph.D.
Polymer Laboratory

Abd-El-Bary, Ph.D.
Polymer Laboratory

Richard Roberts, Ph.D.
Mechanical Behavior Laboratory

Richard Moore Spriggs, Ph.D.
Physical Ceramics Laboratory

George Krauss, Jr., Sc.D.
Electron Microscope Laboratory

Center for Marine and Environmental Studies

James Marshall Parks, Ph.D.
Director

Joseph Robert Merkel, Ph.D.
Director, Marine Biochemistry Laboratory

Adrian F. Richards, Ph.D.
Director, Marine Geotechnical Laboratory

Sidney Samuel Herman, Ph.D.
Director, Marine Biology Laboratory

Thomas Clement Cheng, Ph.D.
Director, Institute for Pathobiology

Saul Benjamin Barber, Ph.D.
Physiology of Invertebrates

Edward J. Benz, M.D.
Medical Microbiology

Arthur William Brune, Ph.D.
Hydrology

Bobb Carson, Ph.D.
Oceanic Sedimentology

Robert William Coughlin, Ph.D.
Air Pollution Studies

Jacob De Rooy, M.A.
Econometric Modeling

Alfred James Diefenderfer, Ph.D.
Analytical Chemistry

Walter H. Graf, Ph.D.
River and Oceanographic Hydraulics

Terence J. Hirst, Ph.D.
Geotechnical Measurements

Matthew H. Hulbert, Ph.D.
Analytical Chemistry

Robert L. Johnson, Ph.D.
Sanitary Engineering

E. Everett MacNamara, Ph.D.
Bioenvironmental Research, Soils

Jack B. Pearce, Ph.D.
Benthic Ecology

John Donald Ryan, Ph.D.
Sedimentology

Alan Hugh Stenning, Sc.D.
Geophysical Fluid Mechanics

Theodore Alfred Terry, Ph.D.
Instrument Design

Wesley J. Van Sciver, Ph.D.
Marine Optics, Nuclear Applications

Institute for Pathobiology

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Director

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Medical Microbiology

Ned Heindel, Ph.D.
Synthesis of Drug Candidates

Sidney S. Herman, Ph.D.
Director of Marine Biology Laboratory; Pollution Biology

Eugene M. Landis, Ph.D., M.D.
Pathophysiology of Blood Vessels

Richard G. Malsberger, Ph.D.
Virology

Joseph R. Merkel, Ph.D.
Microbial Biochemistry

Hayden N. Pritchard, Ph.D.
Pesticide Pollution Ecology

Randall W. Snyder, Jr., M.D.
Medical Parasitology

Center for Information Science

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Director

Andrew James Kasarda, Ph.D.
Associate Director

Herbert Rubenstein, Ph.D.
Associate Director, Research

John J. O'Connor, Ph.D.
Systems Evaluation

John William Humes, Ph.D.
Assistant to the Director

Robert Featherstone Barnes, Jr., Ph.D.
Mathematical Linguistics

James Sproat Green
Special Projects

Louis W. Stern
Batch Services

Lawrence J. Davis
Interactive Services

Associate

Robert Clifford Williamson, Ph.D.
Man-Machine Interface

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

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

Lajos G. Nagy
Visiting Research Professor, Radiochemistry of Surfaces

Research Associates

David M. Fairhurst, Ph.D.
Elsie Kellerman, Ph.D.
Jean Lavelle
Michael Wilkinson, Ph.D.

Center for Business Economics and Urban Studies

J. Richard Aronson, Ph.D.
Director, Business Economics Program

Leo Van Hoey, Ph.D.
Director, Urban Studies Program

Leonard Ruchelman, Ph.D.
Government

Carl Beidleman, Ph.D.
Finance

Stephen Bryen, Ph.D.
Government

Jacob De Rooy, Ph.D.
Economics

James McIntosh, Ph.D.
Social Relations

Center for the Application of Mathematics

Ronald Samuel Rivlin, Sc.D.
Director

Gerald F. Smith, Ph.D.
Eric Varley, Ph.D.
Robert F. Barnes, Jr., Ph.D.
Gregory T. McAllister, Ph.D.
Michael P. Mortell, Ph.D.
Philip A. Blythe, Ph.D.
Martin L. Richter, Ph.D.
Eric P. Salathe, Ph.D.
Rolf K. Adenstedt, Ph.D.
Dominic Edelen, Ph.D.
Anastasios Kydoniefs, Ph.D.
Ramamirtham Venkataraman, Ph.D.

Kenneth N. Sawyers, Ph.D.
Executive Officer

Fritz Engineering Laboratory

Lynn Simpson Beedle, Ph.D.
Director

George C. Driscoll, Jr., Ph.D.
Associate Director

Bruce A. Laub, M.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, Plastic Analysis Division

Ti Huang, Ph.D.
Director, Structural Connections Division

Alexis Ostapenko, Ph.D.
Director, Structural Stability Division

Roger G. Slutter, Ph.D.
Director, Operations Division

Celal N. Kostem, Ph.D.
Chairman, Computer Systems Group

Joseph A. Corrado, M.S.
Engineer of Tests

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.
George R. Irwin, Ph.D.
David A. Vanhorn, Ph.D.
B. T. Yen, Ph.D.

Institute of Fracture and Solid Mechanics

George C. M. Sih, Ph.D.
Director

George T. Embley, Ph.D.
Fazil Erdogan, Ph.D.
Ronald J. Hartranft, Ph.D.
Peter D. Hilton, Ph.D.
George F. Irwin, Ph.D.
Arturs Kalnins, Ph.D.
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

Fred R. Sauerwine, Ph.D.
Associate Project Director

Joseph Kovacs
Technician

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

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 Application of Mathematics
B.S., Brown, 1963; Ph.D., 1967.

Eugene Murray Allen (1967)
Research Professor in Chemistry and Director, Polymer 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.

Thomas Althouse (1971)
Visiting Assistant Professor of Fine Arts
B.A., Oberlin, 1948; M.F.A., Tyler School of Art, 1968.

Carlos J. Alvare (1968, 1969)
Visiting Associate Professor of Fine Arts
B.A., Yale University, 1947; M.C.P., Penn, 1952.

David C. Amidon, Jr. (1965, 1971)
Lecturer in Social Relations
B.A., Juniata College, 1957; M.A., Penn State, 1959.

Edward Delbert Amstutz (1938, 1947)
Howard S. Bunn Distinguished Professor of Chemistry
B.S., Wooster, 1930; M.S., Institute of Paper Chemistry, 1932; Ph.D., Cornell, 1936; D.Sc., Wooster, 1969.

Norman Craig Anderson (1966, 1968)
Business Manager, Athletics
B.S., Lehigh, 1960; M.S., Southern Illinois, 1964.

Charles Arthur Apple (1970)
Instructor in Metallurgy and Materials Science
B.S., Florida State, 1967; M.S., Lehigh, 1969.

Kemal Arin (1969)
Assistant Professor of Mechanical Engineering and 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, 1968)
Associate Professor of Economics
A.B., Clark, 1959; M.A., Stanford, 1961; Ph.D., Clark, 1964.

Fred Assenheimer (1970, 1971)
Assistant Executive Secretary, Alumni Association
B.S., Lehigh, 1966.

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
B.Sc. and Dip. Ing., Isreal Institute of Technology, 1949; M.S., University of Michigan, 1956; Ph.D., 1960.

Howard J. Axon (1971)
National Science Foundation Visiting Senior Scientist in Metallurgy and Materials Science
B.A., Sheffield University (England), 1945; Ph.D., Oxford, 1947.

Alice Frances Bahr (1971)
Assistant Reference Librarian
B.A., Temple, 1968; M.L.S., Drexel, 1971.

John Ross Baker (1962, 1971)
Lecturer in English
B.A., Rice, 1952; M.A., 1954.

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 and Chairman of the Department of Biology
B.S., Rhode Island State, 1941; Ph.D., Yale, 1954.

Richard H. Barkalow (1970)
Instructor in Metallurgy and Materials Science
B.S., Rensselaer, 1963; M.S., Case-Western Reserve, 1965.

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., University of Nebraska, 1952; M.S., 1953; Ph.D., University of Utah, 1957.

Donald Delyle Barry (1963, 1970)
Professor of Government
A.B., Ohio, 1956; M.A., Syracuse, 1959; Ph.D., 1963.

Allen Merril Barstow (1967)
Instructor in Romance Languages
B.S., Lehigh, 1955; M.A., Penn, 1966.

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.

Carl Robert Beidleman (1967)
Assistant Professor of Management and Finance
B.S., Lafayette, 1954; M.B.A., Drexel, 1961; Ph.D., Penn, 1968.

Peter Beidler (1963, 1968)
Assistant Professor of English
B.A., Earlham, 1962; M.A., Lehigh, 1965; Ph.D., 1968.

Raymond Bell (1966)
Instructor in Education
Teaching Certificate, St. John's College, York (England), 1961; M.Ed., Temple, 1966.

Robert W. Bell (1969)
Director, University Book Store
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.

Raymond W. Bennett (1971)
Assistant Professor of Psychology
B.A., New College, 1967; M.A., Michigan, 1970; Ph.D., 1971.

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.

Vahram Biricikoglu (1966, 1968)
Assistant Professor in Mechanics
Dipl. Ing., Instanbul State University, 1962; M.S., Lehigh, 1964.

Claire C. Biser (1970)
Assistant to the 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.

Michael G. Bolton (1971)
Associate Director of Development and Director of Corporate and Foundation Resources
B.A., 1966; M.B.A., Lehigh, 1967.

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, 1960)
Associate Professor of International Relations
A.B., Washington, 1942; LL.B., Harvard, 1949; Ph.D., Washington, 1957.

Francis Mario Brady, Jr. (1955, 1970)
Associate Professor of Accounting
B.S., Drexel, 1950; M.B.A., Lehigh, 1957. C.P.A., Pennsylvania, 1955.

Siham Chucri Braidi (1966)
Instructor in Mathematics
B.S., American University of Beirut, 1964; M.S., 1966.

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)
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B.S., Northwestern, 1957; LL.B., Georgetown, 1961; LL.M., 1963.

Arthur Lionel Brody (1957, 1971)
Professor and Chairman of the Department 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.
(On leave 1971-1972.)

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 Maria Brozek (1959, 1963)
Research Professor of Psychology
Ph.D., Charles (Prague), 1937.

Arthur William Brune (1952, 1971)
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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)
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B.S., Lehigh, 1962; M.S., 1964.

Ann Cali (1971)
Assistant Professor of Biology
B.S., University of 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)
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Bobb Carson (1971)
Instructor in Geology
B.A., Carleton College, 1965; M.S., Washington, 1967; Ph.D. Washington, 1971.

Alfred Joseph Castaldi (1964, 1966)
Associate Professor and Director, Division of Elementary 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.

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Assistant Professor of Chemical Engineering
B.S, Brooklyn Polytechnic, 1964; M.S., 1967; Ph.D., 1970

John McIlvain Cheezum, Jr. (1964)
Assistant Director, Office of Research
A.B., Penn, 1964.

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Professor of Mechanical Engineering and Mechanics
B.Ch.E., Cooper Union, 1956; M.S , Carnegie-Mellon, 1959; Ph.D., Michigan, 1961.

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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, Institute of Pathobiology
A.B., Wayne State, 1952; M.S., Virginia, 1956; Ph.D., 1958.

Janet D. Chorney (1971)
Assistant to the Director, Public Information
B.A., Moravian, 1969; M.A., Rutgers, 1971.

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Professor of Metallurgy and Materials Science
B.S., Chungking University, 1945; M.S., Carnegie-Mellon, 1954; Ph.D., 1957.

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University Distinguished Professor
B.A., Wooster, 1935; Ph.D., Yale, 1939; LL.D., College of Notre Dame (Md.), 1966.

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.

Harold Clarke(1967)
Lecturer and Technician in Physics

Roy C. Claypool (1971)
Part-time Lecturer in Education
B.S., Shippensburg, 1959; M.Ed., Penn State, 1964.

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.
(On leave fall semester, 1971.)

Robert Carlton Cole (1964, 1970)
Associate Director of University Publications
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.
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Mary A. Conahan (1971)
Assistant Professor in Education
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George Powell Conard II (1952, 1960)
Professor and Chairman of Metallurgy and Materials Science, Director of Magnetic Materials Laboratory
B.S., Brown, 1941; M.S., Stevens Institute, 1948; Sc.D., M.I.T., 1952.

Samuel Irvin Connor (1961)
Director of Public Relations
B.A., Lehigh, 1949.

Percy Elwood Corbett (1964)
Adjunct Professor of International Relations
M.A., McGill University (Canada), 1915; B.A., Oxford, 1920; M.A., 1925; LL.D. (Hon.), Melbourne (Australia), 1938; D.C.L. (Hon.), McGill, 1961.

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Instructor in Economics
B.B.A., Clark, 1955; M.S., University of Connecticut, 1957.

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Instructor in Civil Engineering
B.S., Detroit, 1963; M.S., Lehigh, 1965.

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Professor of Chemical Engineering; Associate Director, Center for Marine and Environmental Studies
B.S., Fordham, 1956; Ph.D., Cornell, 1961. P.E., New Jersey, 1964.
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John Nelson Covert (1967)
Assistant Professor of Physical Education, Varsity Cross County 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.

Cloyd Criswell (1947, 1971)
Associate Professor of English
B.S. in Ed., Millersville State, 1933; M.A., New York, 1937.

Mildred J. Crosby (1962)
Psychometrician, Counseling

Robert Benjamin Cutler (1954, 1962)
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Professor of Electrical Engineering
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Part-time Lecturer in Education
B.S., Ed., Bloomsburg State, 1952; M.S., Ed., Temple, 1956; Ed.D., 1968.

George F. Dalton (1970)
Executive Director, Institute for the Development of Riverine and Estuarine Systems
B.S., United States Naval Academy, 1938.

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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.

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Assistant Professor in Military Science
B.S., Loyola College, 1967. Captain, U.S. Army.

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Professor and Chairman of the Division of Speech
B.L.I., Emerson, 1929; Cert., American Academy of Dramatic Arts, 1930; M.A. (Hon.), Emerson, 1958.

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Assistant Professor of Mathematics
A.B., West Virginia, 1962; M.S., 1962; Ph.D., Carnegie-Mellon, 1969.

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Associate Professor of Classics
B.S., Temple, 1938; M.A., Penn, 1960; Ph.D., 1965.

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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.

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Assistant Librarian
A.B., Allegheny, 1939; B.S. in L.S., Syracuse, 1940.

Jacob De Rooy (1967, 1969)
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A.B., Rutgers, 1963; A.M., 1965; Ph.D., 1969.

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Associate Professor of Chemistry
B.S., Pittsburgh, 1957; Ph.D., M.I.T., 1961.

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Assistant to the Dean, Graduate School

Ernest Nevin Dilworth (1949, 1967)
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Ph.B., Kenyon, 1933; M.A., Pittsburgh, 1937; Ph.D., Columbia, 1948.

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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.

George Douris (1964)
Part-time Lecturer in Education
B.A., Philadelphia Museum School of Art, 1953; M.F.A., Temple, 1958.

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Adjunct Professor of Management and Finance
A.B., Lafayette, 1940; L.L.B., Yale, 1948.

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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.

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Part-time Lecturer in Education
B.S., Millersville State, 1941; Ed.M., Temple, 1947; Ed.D., 1960.

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Associate Professor of International Relations
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Frederick Homer Dunlap (1965)
Assistant Professor of Physical Education, Varsity Head Football Coach
B.A., Colgate, 1950.

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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
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Assistant to Dean of Residence
B.A., Swarthmore, 1921.

Arthur Roy Eckhardt (1951, 1956)
Professor and Chairman of the Department of Religion
B.A., Brooklyn, 1942; B.D., Yale, 1944; Ph.D., Columbia, 1947; L.H.D., Hebrew Union College, Jewish Institute of Religion (1969).

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Professor, Center for the Application of Mathematics
B.E.S., Johns Hopkins, 1954; M.S.E., 1956; Ph.D., 1965.

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Professor of Education, Director, Counseling Service
A.B., West Virginia, 1951; M.S., University of Miami, 1953; Ph.D., Penn State, 1960.

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B.S., Cairo University, 1954; M.S., 1958; Ph.D., Berkeley, 1963.

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Professor of Music
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Assistant Dean, College of Arts and Science, and Associate Professor of History
A.B., Yale, 1943; A.M., Harvard, 1947; Ph.D., 1952.

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Associate Professor of History
B.S., Memphis State, 1955; M.A., 1957; Ph.D., Tulane, 1962.

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B.S., Illinois, 1964. Captain, U.S. Army.

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Professor of Physics
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Professor of Mechanics
Yuk. Muh., Technical Institute of Istanbul, 1948; Ph.D., Lehigh, 1955.

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Research Associate, Center for Surface and Coatings Research
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Administrative Assistant, Center for Surface and Coatings Research
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Instructor in Physical Education
B.S. Delaware, 1963

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Professor of Civil Engineering
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Assistant Director, Placement Services
B.A., Moravian, 1966; M.A., Lehigh, 1970.

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B.S., West Chester, 1956; M.Ed., Temple, 1960.; Ed.D., Lehigh, 1970.

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Professor of Physics
B.S., in E.E., Lehigh, 1953; B.S., in Phys., 1954; M.S., 1955; Ph.D., 1958.

Roy Foster (1967)
Assistant Director, Public Information
A.B., Ursinus, 1951.

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McCann Professor of Chemical Engineering
B.S., Texas, 1928; M.S., 1930; Ph.D., Michigan, 1938. P.E., Michigan, 1947.

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Professor and Chairman of the Department of Chemistry
B.S., University of Chicago, 1936; Ph.D., 1938.

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Professor of Physics
B.S., Lehigh, 1959; Ph.D., Rochester, 1963.

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Professor of English
B.A., Penn State, 1948; M.A., Chicago, 1949; Ph.D., Penn, 1953.

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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

Bruce Dale Fritchman (1969)
Assistant Professor of Electrical Engineering
B.S., Lehigh, 1960; E.P., 1961; M.S., 1963; Ph.D., 1967.

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A.B., Hobart, 1935; M.A., Rochester, 1941; Ed.D., Buffalo, 1953.

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Instructor in Military Science
Staff Sergeant, U.S. Army.

Edward J. Gallagher (1969, 1970)
Assistant Professor of English
B.S., St. Joseph's College, 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
A.B., Duke, 1944; A.M., Harvard, 1945; Ph.D., 1950.

Berry Gargal (1969)
Associate Librarian, Mart Science and Engineering Library
A.B., Vassar, 1952; M.L.S., New York at Albany, 1969.

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.

Leanor Ruth Gilbert (1930, 1943)
Recorder

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Assistant Varsity Football Coach and Varsity Lacrosse Coach
B.A., Syracuse, 1961.

Audrey L. Gilmartin (1971)
Part-time Instructor in Education
B.S., Kutztown State, 1950.

Frederick Robert Gladeck (1966)
Instructor in International Relations
B.A., Lehigh, 1960; M.A., Penn, 1964.

Elmer William Glick (1949, 1952)
Treasurer
B.A., Lehigh, 1933.

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Accountant
B.S. in Bus. Adm., Lehigh, 1958.

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Assistant Football Coach
B.S., Villanova, 1963; B.A., 1970.

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Instructor in Electrical Engineering
Dipl. Ing., Technical University (Karlsruhe), 1967; M.S., Lehigh, 1969.

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Associate Professor of Metallurgy and Materials Science
B.S., M.I.T., 1960; S.M., 1962; Sc.D., 1964.

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Assistant Professor of Economics
B.B.A., Wisconsin, 1954; M.B.A , 1959; Ph.D., 1966.

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Professor and Chairman of the Department of Industrial Engineering
S.B., M.I.T., 1938; M.S., Lehigh, 1949. P.E., Pennsylvania, 1949.

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Psychiatrist, Health Service
B.S., Penn State, 1933; M.D., Jefferson Medical College, 1937.

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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.

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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.

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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.

Clark W. Hahn (1967)
Assistant Accountant

Walter Charles Hahn, Jr. (1963, 1967)
Associate Professor of Metallurgy and Materials Science
B.S., Lafayette, 1952; M.S., Penn State, 1958; Ph.D., 1960.

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Professor of History
A.B., Princeton, 1940; M.A., Yale, 1947; Ph.D., Northwestern, 1953.
(On leave 1971-1972.)

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Professor of Mathematics
B.S., Michigan, 1939; Ph.D., Cornell, 1943.

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Director, Community Relations
B.S., Northwestern, 1954; M.S., 1956.

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Assistant Dean of Student Life
B.A., Lincoln University, 1965.

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Assistant Professor of English
B.A., Wagner, 1963; M.A., Ohio, 1964; Ph.D., 1966.

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Assistant Professor of Mechanics
B.S., Lehigh, 1963; M.S., 1964; Ph.D., 1966.

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Postdoctoral Research Associate in Chemical Engineering
M.S.,Technical University (Prague), 1960; Ph.D., Czech Academy of Science (Prague), 1965.

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B.A., Lehigh, 1947; M.A., 1949; Ph.D., 1957.

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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.

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Associate Professor of Chemistry
B.S., Lebanon Valley, 1959; M.S., Delaware, 1961; Ph.D., 1963.

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Instructor in Education
B.A., Muhlenberg, 1968; M.Ed., Lehigh, 1970.

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Professor of Biology
B.S., Georgetown, 1953; M.S., Rhode Island, 1958; Ph.D., 1962.

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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.

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B.S., Penn, 1949; M.A., 1950; M.A., Columbia, 1951: Ph.D., Penn, 1956.

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Assistant Professor of Fine Arts
B.S., Kansas State, 1959; M.A., M.F.A., University of Iowa, 1963.

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Assistant Professor of Electrical Engineering
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Donald John Hillman (1960, 1964)
Professor and Chairman of the Department of Philosophy and Director, Center for Information Science
B.A., Cambridge (England), 1955; M.A., 1959; M.Litt., 1962.

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B.S., Lehigh, 1965; M.S., Harvard, 1966; Ph.D., 1969.

Terence John Hirst (1968)
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Professor and Chairman of the Department of Management and Finance
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B.S., Old Dominion College, 1964.

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Director of Development
B.S., Lehigh, 1958; M.S., 1969.

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B.S., Lehigh, 1959; M.S., 1960; Ph.D., 1966.

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B.S., Lehigh, 1956; M.S., 1957; Ph.D., 1963.

Frank Scott Hook (1952, 1965)
Professor of English
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B.S., Salem College, 1964; M.S., Pittsburgh, 1967; M.S., N.Y.U., 1971.

Lynne H. Hott (1971)
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B.S., Pittsburgh, 1967; Stevens Institute, 1970.

Richard Hsia (1969)
Postdoctoral Fellow in Chemistry
B.S., Cheng Kung University (Taiwan), 1963; Ph.D., McGill University (Canada), 1969.

Chua-Chih Hsiung (1952, 1960)
Professor of Mathematics
B.S., National Chekiang (China), 1936; Ph.D., Michigan State, 1948.

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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)
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Assistant Professor of Philosophy
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Boeing University, Professor of Mechanics
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Instructor in Civil Engineering
B.S., Central College (Bangalore, India), 1948; B.E., College of Engineering (Poona, India), 1953; M.S., Washington State, 1966.

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George Robert Jenkins (1948, 1963)
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B.A., Colorado, 1936; Ph.M., Wisconsin, 1938.

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A.B., Southern California, 1934; M.A., 1935; Ph.D., 1940.

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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 Systems Analyst, Center for Information Science
B.A., Penn State, 1962; M.S., Lehigh, 1966; Ph.D., 1968.

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Assistant Professor of Psychology
B.S., Rensselaer, 1964; M.S., Lehigh, 1966; Ph.D., 1968.

John Daniel Keefe (1965, 1971)
Assistant Professor of Economics
B.S., Lehigh, 1948; M.A., Miami (Florida), 1955.

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Manager, Fraternity Services
B.S., Lehigh, 1948.

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Part-time Lecturer in Education
B.S., West Chester, 1934; M.S., Penn, 1940; Ed.D., 1951.

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Lecturer in Education
B.S., Millersville State, 1949; M.A., 1953; D.Ed., 1956.

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Research Associate, Center for Surface and Coatings Research
A.B., Mt. Holyoke, 1959; Ph.D., Penn, 1963.

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Assistant Purchasing Agent

Kathleen A. Kemmerle (1970)
Systems Programmer
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.

Yong Wook Kim (1968)
Assistant Professor of Physics
B.S., Seoul National University, 1960; M.S., 1962; Ph.D., Michigan, 1968.

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Professor of Mathematics
B.S., Kentucky, 1958; M.S., 1959; Ph.D., 1962.

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Part-time Lecturer in Education
B.A., Moravian, 1954; B.D., Moravian Theological Seminary, 1957; M.A., Butler, 1962; Ed.D., Lehigh, 1970.

Charles Edward Klatt (1969)
Assistant Professor of Military Science
B.S., Michigan, 1963. Captain, U.S. Army.

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Production Assistant, University Publications
B.A., Muhlenberg, 1970.

Kamil Klier (1967, 1968)
Associate Professor of Chemistry
B.S., Chemico-Technological University (Prague), 1954.

Alfred Paul Koch (1946, 1969)
Professor of Accounting
B.S., Bloomsburg State, 1939; M.S., Bucknell, 1940. C.P.A., Pennsylvania, 1952.

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Assistant 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.
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Charles Stephen Kraihanzel (1962, 1970)
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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.

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George Krauss, Jr. (1963, 1966)
Associate Professor of Metallurgy and Materials Science
B.S., Lehigh, 1955; M.S., M.I.T., 1958; Sc.D., 1961.

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Assistant Professor of Biology
A.B., Brown, 1963; Ph.D., Yale, 1968.

Philip L. Kreider (1970)
Associate Director, University Health Service
A.B., Dartmouth, 1953; M.D., Temple, 1957.

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Instructor in Military Science
MSG, U.S. Army.

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Associate Professor of Management and Finance
B.A., Susquehanna, 1941; M.S., Bucknell, 1947; Ph.D., New York, 1958.

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Assistant Professor in Military Science
B.S., St. Peter's College (New Jersey), 1960. Major, U.S. Army.

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Instructor in Education
B.A., Fairleigh Dickinson, 1963

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Research Associate in Physics
B.S., Muhlenberg, 1962; M.S., Lehigh, 1964; Ph.D., 1966.

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Assistant Professor, Center for the Application of Mathematics
B.Sc., Athens (Greece), 1963; M.Sc., Nottingham (England), 1965; Ph.D., 1967.

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Instructor in Management and Finance
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Assistant Professor of Mathematics
B.A., Penn, 1958; M.A., 1960; Ph.D., 1969.

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B.S., Penn, 1922; M.S., 1924; M.D., 1926; Ph.D., 1927; M.S. (Hon.), Yale 1938.

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B.S., Lehigh, 1959; B.A., 1961; M.A., Pittsburgh, 1962; Ph.D., 1970.

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Professor of Electrical Engineering
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Professor of Physical Education and Director of the Division of Athletics and Physical Education
B.S., St. Lawrence, 1939.

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Professor and Chairman of the Department of History
B.A., Long Island, 1949; M.A., N.Y.U., 1950; Ph.D., 1960
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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.

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Director, Center for Surface and Coatings Research
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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.

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Instructor in Aerospace Studies
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B.A., University of Maine, 1969; M.L.S., New York at Albany, 1971.

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Consultant, Office of the Vice President for Development
B.S., 1930; M.A., 1933; L.H.D., Washington & Jefferson.

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Professor and Chairman of the Department of Government
B.S. Ed., Illinois, 1948; M.A., Colgate, 1950; Ph.D., Boston University, 1958.
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Consulting Physician, Health Service
B.S., Penn, 1929; M.D., 1932.

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Associate Professor of Electrical Engineering
B.S., in E.E., M.I.T., 1945; M.S., Lehigh, 1947; Ph.D., Penn State, 1952. P.E., Pennsylvania, 1958.

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Professor and Chairman of the Division of Journalism
B.A., St. Joseph's (Canada), 1941; M.A., Syracuse, 1948.

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B.S., King's College, 1965; M.B.A., University of Scranton, 1967.

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B.S., Penn, 1952; M.S., 1959.

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Professor and Chairman of the Department of Physics
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Assistant Professor of Geology
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Lecturer in Electrical Engineering
B.S.E.E., Virginia, 1962.

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Head Football Trainer and Instructor in Physical Education
B.S., Mississippi State, 1965.

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Adjunct Professor of Education
A.B., Columbia, 1922; M.A., 1923; LL.D., Fairleigh Dickinson 1956; L.H.D. (Hon.), Bloomsburg, 1961.

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Associate Professor of Philosophy and Chairman of the Division of Philosophy
B.A., Wartburg, 1955; B.D., Lutheran Theological Seminary, 1958; M.A., Penn, 1959; Ph.D., 1964.
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Professor of Biochemistry
B.S., Moravian, 1948; M.S., Purdue, 1950; Ph.D., Maryland, 1952.

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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)
Associate 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.

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Visiting Instructor in Romance Languages
Certificate, Kivukoni College (Tanzania), 1962; Certificate, Mlonot Company Ltd. (Tel Aviv), 1965.

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Assistant Accountant
B.S., Penn State, 1964.

Paul Theodore Miller (1961)
Assistant 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.

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Intern Supervisor of Education
B.S., Kutztown State, 1958; M.A., Lehigh, 1962.

Robert Hugh Mills (1964, 1967)
Professor and Chairman of the Department of Accounting
B.S., Colorado, 1949; M.S., 1955; Ph.D., Wisconsin, 1960.
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Samuel Harold Missimer (1950, 1962)
Director of Admission
B.A., Lehigh, 1950.

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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.

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Professor of Accounting
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Adjunct Professor of Psychology
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Assistant Professor, Center for the Application of Mathematics
B.Sc., University College (Cork, Ireland), 1961; M.Sc., 1963; M.S., Cal Tech, 1964; Ph.D., 1967.

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Director of University Publications
B.S., Marshall, 1959; M.A., Iowa, 1962.

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A.B., Muhlenberg, 1969; M.S.L.S., Syracuse, 1970.

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Associate Professor of Geology
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Visiting Research Associate Professor, Center for Surface and Coatings Research
Diploma, Chemical Engineering Polytechnic University (Budapest), 1953; Doctor of Technology, 1960.

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Instructor in Centennial School
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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.

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Instructor in Physical Education
B.S., Rutgers, 1963.

James Walter Niemeyer (1968, 1970)
Executive Secretary, Alumni Association
B.S., Lehigh, 1943.

Julius Nimmons (1970)
Lecturer in History
B.A., Morehouse College, 1962; M.A., Atlanta, 1968.

Samuel Gilbert Nord (1964)
Assistant Professor in Psychology and Director, Bioelectric Laboratory
B.A , Delaware, 1956; M.A., 1958; Ph.D., Brown, 1963.

Michael Richard Notis (1967, 1969)
Assistant Professor of Metallurgy and Materials Science
B.S., Lehigh, 1960; M.S., 1963; Ph.D., 1969.

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.

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Professor of Chemistry
Sc.B., Brown, 1953; Ph.D., M.I.T., 1956.

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Associate Professor of Electrical Engineering
B.S., Lehigh, 1960; M.S., 1963; Ph.D., 1967.

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Assistant Superintendent of Buildings and Grounds
B.S., Penn State, 1947.

Thomas Russell Ortolano (1965)
Assistant Professor of Chemistry
B.S., Loyola University of the South, 1960; Ph.D., Louisiana State, 1964.

Joseph C. Osborn (1946, 1961)
Associate Professor of Mechanics
B.S.M.E., Purdue, 1933; M.S., Michigan, 1946. P.E., Michigan, 1955.

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Professor of Civil Engineering
Dipl. Ing., Munich Institute of Technology, 1951; Sc.D., M.I.T., 1957.

William Wallace Oswalt, Jr. (1956)
Part-time Lecturer in Education
A.B., Muhlenberg, 1949; Ed.M., Temple, 1950; Ed.D., 1962.

Eric Van Tine Ottervik (1966, 1969)
Vice Provost
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.

Anthony Packer (1946, 1950)
Assistant Professor of Physical Education and Assistant to the Director in charge of Fields
B.S., St. Lawrence, 1938.

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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.

Paul Croce Paris (1955, 1965)
Professor of Mechanics
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Professor of Biology
S.B., M.I.T., 1933; A.M., Harvard, 1935; Ph.D., M.I.T., 1939.

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Instructor in Education
B.A., Connecticut College, 1956.

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Professor of Geology and Director, Center for Marine and Environmental Studies
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Preston Parr (1949, 1970)
Dean and Vice President for Student Affairs
B.S., Lehigh, 1943; M.S., 1944.

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Instructor in Education
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Bursar
B.S., King's College, 1960.

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B.A., Wesleyan, 1962; M.B.A., Michigan, 1964.

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Director, Health Service
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Associate Professor of Economics
A.B., New Hampshire, 1953; M.S., Florida State, 1958; Ph.D., Virginia, 1963.

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Distinguished Professor and Chairman of the Department of Mathematics
A.B., Case-Western Reserve, 1932; A.M., Harvard, 1933; Ph.D., 1935; D.Sc. (Hon.), Case-Western Reserve, 1957.

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Administrative Assistant to Director, Health Service
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William Leroy Quay (1963, 1970)
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Francis Joseph Quirk (1950, 1953)
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Dipl., Rhode Island School of Design, 1929.

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Instructor in Electrical Engineering
B.Sc., Engineering, Banaras, 1949; A.I.I.Sc., Bangalore, 1952.

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Associate Executive Secretary, Alumni Association and Editor, Lehigh Alumni Bulletin
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B.S., Newark College of Engineering, 1942; M.S., Stevens Institute, 1949; M.S., Worcester Polytechnic, 1970. P.E., New Jersey, 1961; Pennsylvania, 1970.

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Assistant Professor of Education and Coordinator of Educational Placement
B.A., Smith, 1947; M.Ed., Lehigh, 1965; Ed.D., 1969.

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Assistant to the Vice President—Research, and Assistant Professor, Metallurgy and Materials Science
B.S., Lehigh, 1961; S.M., M.I.T., 1963; Sc.D., 1966.

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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.

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B.S., Drexel, 1961; M.S., Lehigh, 1962; Ph.D., 1964.

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Assistant Professor of Mechanical Engineering and Mechanics
B.S., Bucknell, 1964; M.S., Lehigh, 1965; Ph.D., 1968.

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Instructor in Romance Languages
Bach., University of St. Thomas (Bogota), 1953; Licentiatus, University of St. Thomas (Rome), 1961.

Herbert Rubenstein (1967)
Professor of Philosophy and Associate Director, Research, Center for Information Science
B.A., Penn, 1942; M.A., 1943; Ph.D., Columbia, 1949.

Leonard I. Ruchelman (1969)
Associate Professor of Government
B.A., Brooklyn College, 1954; Ph.D., Columbia, 1965.

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B.A., Hunter, 1940; M.A., Columbia Teacher's College, 1958.

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Professor of Geology and Chairman of the Department of Geological Sciences
B.A., Lehigh, 1943; M.S., 1948; Ph.D., Johns Hopkins, 1952.
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B.A., Ohio State, 1960; M.A., 1963; Ph.D., 1969.

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Sc.B., Brown, 1960; M.S., Princeton, 1963; Ph.D., Brown, 1965.

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Professor of Education and Director, Summer Sessions
B.S., Pittsburgh, 1951; M.Ed., 1955; Ed.D., 1962.

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Associate Librarian
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Associate Professor of Mechanics
B.Sc.E., Cooper Union, 1953; M.S., Lehigh, 1957; Ph.D., 1963.

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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
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William Edward Schiesser (1960, 1963)
Professor of Chemical Engineering and Manager, User Services, Computing Center
B.S., Lehigh, 1955; M.A., Princeton, 1958; Ph.D., 1960.

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Assistant Professor of Military Science
B.S., LaSalle, 1963. Captain, Infantry, U.S. Army.

Edward Wilfred Schmitt (1968)
Instructor in Management and Finance
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 English
B.A., Indiana, 1967; M.A., Colorado State, 1969.

Stanley Robert Schultz (1966)
Instructor in Physical Education, Varsity Baseball Coach
B.A., Trenton State, 1964.

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Professor of Economics and Finance
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.

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.

William Gerald Shade (1966, 1969)
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Assistant to the Director, Public Information
B.S., Syracuse, 1970.

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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.

M. Wayne Shiveley (1968)
Instructor in Industrial Engineering
B.S., Missouri, 1960; B.S., 1965; M.S., 1967.

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Associate Professor of Psychology
A.B., Lycoming, 1954; M.A., Brown, 1960; Ph.D., 1962.

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Assistant Football and Lacrosse Coach and Instructor in Physical Education
B.S., Gettysburg, 1963.

Robert Peter Shurtleff (1963, 1964)
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.

George C. M. Sih (1958, 1965)
Professor of Mechanics
B.S., Portland, 1953; M.S., New York, 1957; Ph.D., Lehigh, 1960.

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)
Research Assistant Professor and Assistant to Director, Center for Surface and Coatings Research
B.S., West Virginia, 1961; Ph.D., 1967.

Marvin Howard Simmons (1970)
Art Director, 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.

Herbert Bancroft Skerry (1967)
Assistant Professor of Mathematics
A.B., Harvard, 1954; M.S., Wisconsin, 1958; Ph.D., Michigan, 1967.

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.

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Assistant Professor of Management and Finance
B.S., Rensselaer, 1962; M.S., Case-Western Reserve, 1964; Ph.D., Rensselaer, 1969.

Gerald Francis Smith (1965)
Professor, Center for the Application of Mathematics
B.S., Buffalo, 1953; Ph.D., Brown, 1956.

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Director, Computing Laboratory
B.A., Wesleyan, 1950; M.A., 1952; B.S., Canisius, 1958.

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Assistant Librarian, Acquisitions
A.B., Oberlin, 1940; M.L.S., Drexel, 1966.

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Professor of Physics
B.S., Lehigh, 1950; M.S., 1951; Ph.D., Princeton, 1957.

William Adams Smith, Jr. (1955, 1968)
Professor of Industrial Engineering and Director, Center for Information Science
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.

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Director, Materials Research Center and Associate Professor, Metallurgy and Materials Science and Chemistry
B.S., Maine, 1951; Ph.D., M.I.T., 1954.

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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.

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B.A., University of Scranton, 1962; M.A., 1964; Ph.D., Penn State, 1969.

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Coordinator of Volunteer Community Services
A.B., Muhlenberg, 1965; M.S.S.W., Columbia, 1967.

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Research Associate in Mechanics
Dipl. Phys., University of Gottingen (Germany), 1962; Dr. Rer. Nat., University of Freiburg (Germany), 1966.

Richard N. Sopko (1961)
Photographer–Draftsman in Civil Engineering

Wilbur Devilla Bernhart Spatz (1946, 1970)
Professor of Physics
B.S., Lafayette, 1930; M.S., Purdue, 1934; Ph.D., New York, 1943.

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B.S., Florida, 1954; M.A., Duke, 1957; Ph.D., 1959.

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Associate Director, Health Service
B.S., Juniata, 1957; M.D., Temple, 1961.

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A.B., Ohio, 1954; M.A., 1955; Ed.D., Indiana, 1965.

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Director of Undergraduate Financial Aid
B.A., Drew, 1962.

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Professor of Aerospace Studies
B.A., Texas, 1948; M.A., Oregon, 1951; Ph.D., Cornell, 1959.
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Assistant Professor of Physical Education and Assistant Director, Physical Education and Intramurals
B.S., West Chester State, 1936; M.S., Penn, 1951.

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Professor of Chemical Engineering
B.S., Lehigh, 1956; M.S.E., Michigan, 1957; Ph.D., 1960.

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B.E.P., Cornell, 1954; M.S., Wisconsin, 1957; Ph.D., 1961.

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Circulation Supervisor, Library

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B.Sc., Glasgow University, 1950; M.S., M.I.T., 1951; Sc.D., 1955.

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Instructor in Education
B.S., Paterson State, 1957; M.S., 1959.

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Assistant Professor of Philosophy
B.A., Temple, 1964; M.A., Lehigh, 1966; Ph.D., 1970.

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.

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Instructor in Education
B.S., Rutgers, 1961; M.S., Temple, 1970.

James Edward Sturm (1956, 1962)
Associate 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.

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Assistant Professor of Aerospace Studies
B.S., Fordham, 1954; M.A., Middle Tennessee State, 1964.
Major, U.S. Air Force.

Alfred Kriss Susskind (1968)
Professor and Chairman of the Department of Electrical Engineering
B.B.E., B.S., Brooklyn Polytechnic, 1948; S.M., M.I.T., 1950.

Hugh T. Sutherland (1967)
Instrument Associate in Civil Engineering

Harry O. Tachovsky (1971)
Instructor in Education
B.S., Kutztown State, 1970.

Peggy A. Talbot (1971)
Instructor in Electrical Engineering
B.A., Cornell, 1966; M.S., Penn, 1969.

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.
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Stephen Kenneth Tarby (1961, 1967)
Associate Professor of Metallurgy and Materials Science
B.S., Carnegie-Mellon, 1956; M.S., 1958; Ph.D., 1962.

Merle W. Tate (1965)
Professor of Education
A.B., Central Wesleyan, 1926; M.A., Montana, 1943; Ed.M., Harvard, 1946; Ed.D., 1947.

Douglas Henley Taylor (1964, 1965)
Assistant Professor of Mathematics
B.S., Cincinnati, 1959; M.S., Illinois, 1961; Ph.D., 1965.

Robert Sayre Taylor, Jr.
Legal Counsel
B.A., Lehigh, 1925; LL.B., Penn, 1928.

Everett Anderson Teal (1945)
Director of Placement and Director of Personnel
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 Application of Mathematics
B.A., New College (Oxford), 1930; M.A., D.Ph.L., 1933.

Robert J. Thornton (1970)
Assistant Professor of Economics
A.B., Xavier, 1965; M.A., Illinois, 1967; Ph.D., 1970.

James A. Tiefenbrunn (1969)
Assistant to the Dean of Residence
B.S., Lehigh, 1966.

John Thomas Hanley Timm (1967)
Instructor in Romance Languages
B.A., Wisconsin State, 1963; M.A., Marquette, 1967.

Peter Tinker (1971)
Instructor in English
A.B., Boston, 1966; M.A., Lehigh, 1969.

Charles Leon Tipton (1964, 1971)
Professor of History
B.A., Southern California, 1958; M.A., 1961; Ph.D., 1964.

Doris Mae Transue (1964)
Nurse, Health Service
R.N., St. Luke's, 1947.

Louis Reed Tripp (1964)
Frank L. Magee Professor of Business Administration
B.A., Union, 1934; Ph.D., Yale, 1942.

Edward J. Trost (1971)
Assistant to the Director of Placement and Personnel Services
A.B., Michigan, 1941; M.A., Lehigh, 1971.

Kenneth Mangold Trumbore (1946)
Assistant Manager of the Supply Bureau
B.A., Moravian, 1940.

Wendell Piggott Trumball (1957, 1958)
Professor of Accounting
B.S., Illinois, 1937; M.A., Michigan, 1941; Ph.D., 1954. C.P.A., Mississippi, 1949.

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Associate Professor of Mathematics
B.S., Lafayette, 1959; M.S., Brown, 1962; Ph.D., Purdue, 1964.

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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.

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Part-time Lecturer in Education
B.A., Case-Western Reserve, 1956; M.A., 1958; Ed.D., 1963.

Kenneth Kai-Ming Tzeng (1969)
Assistant Professor of Electrical Engineering
B.S., National Taiwan, 1959; M.S., Illinois, 1962; Ph.D., 1969.

John Harms Ubben (1960, 1967)
Professor and Chairman of the Department of German
A.B., Central College (Iowa), 1936; M.A., Kentucky, 1937; Ph.D., Chicago, 1942.

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Adjunct Professor in Economics
B.S., Penn, 1934; M.A., 1935; Ph.D., 1960.

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Assistant Professor of Mechanics
B S., Princeton, 1957; M.S., N.Y.U., 1960; Ph.D., Brown, 1964.

Victor Manuel Valenzuela (1957; 1969)
Professor of Romance Languages
B.A., San Francisco State, 1951; M.A., Columbia, 1952; Ph.D., 1965.

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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.

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Postdoctoral Research Associate in Civil Engineering
B.E., University of Tasmania (Hobart), 1963; Ph.D., 1969.

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John Andrews Van Eerde (1960, 1963)
Professor and Chairman of the Department of Romance Languages and Literature
A.B., Harvard, 1938; M.A., 1939; Ph.D., Johns Hopkins, 1953.

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Associate Professor of Sociology
B.S., Pitzemburg College (Belgium), 1938; M.A., Universite de Neuchatel (Switzerland), 1960; Ph.D., Northwestern, 1966.

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Professor and Chairman of the Department of Civil Engineering
B.S., Iowa State, 1951; M.S., 1956; Ph.D., 1959. P.E., Iowa, 1957.

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Professor of Physics
B.S., M.I.T., 1940; Ph.D., Stanford, 1954.

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Reference and Circulation Librarian, Mart Science and Engineering Library
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B.S., Lehigh, 1958; M.B.A., 1960.

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Ph.B., Chicago, 1949; A.M., 1952; Ph.D., Indiana, 1960.
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B.S., Northwestern, 1959; J.D., Chicago, 1962.

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Assistant Accountant
B.S., Penn State, 1969.

Edwin M. Wagner (1966)
Assistant Professor of Aerospace Studies
B.G.E., Omaha, 1965. Major, U.S. Air Force.

James Harold Wagner (1949, 1951)
Registrar, Secretary to the Faculty
B.A., Gettysburg, 1947; M.A., Pennsylvania, 1950.

Walter Barry Wagner (1968)
Instructor in Mechanical Engineering
B.S.M.E., Lehigh, 1962; M.S., Ohio State, 1963.

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Assistant Professor of German
B.A., Berkeley, 1961; M.A., 1964; Ph.D., 1969.

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Associate Professor of Economics
B.S., Clemson, 1958; Ph.D., Virginia, 1963.

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B.S., Shippensburg State, 1950; M.Ed., Penn State, 1958; Ed.D., Columbia, 1967.

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Assistant Professor of Government
A.B., Park College, 1962; M.A., Duke, 1965; Ph.D., 1968.

Richard A. K. Watt (1969)
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A.B., Dartmouth, 1954; M.A., Michigan, 1956; Ph.D., 1966.

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Professor of Military Science
B.S., Carnegie-Mellon, 1942; M.A., George Washington, 1962.
Colonel, Infantry, U.S. Army.

Robert Pey-Ying Wei (1966, 1970)
Professor of Mechanics
B.S., Princeton, 1953; M.S., 1954; Ph.D., 1960.

Andrew R. Weintraub (1966)
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B.A., Rutgers, 1961; M.A., 1964; Ph.D., 1966.

Leonard Andrew Wenzel (1951, 1962)
Professor and Chairman of the Department of Chemical Engineering
B.S., Penn State, 1943; M.S., Michigan, 1948; Ph.D., 1950. P.E., Pennsylvania, 1958.

Donald Bigham Wheeler, Jr. (1947, 1957)
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B.S., Lehigh, 1938; Ph.D., Cal Tech, 1947.

Howard R. Whitcomb (1967)
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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)
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B.S., Lehigh, 1960; M.S., 1962; Ph.D., Arizona State, 1966. P.E., Pennsylvania, 1966.

Joseph Hardy Whritenour (1965)
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Albert Wilansky (1948, 1957
Professor of Mathematics
B.A., Dalhousie (Canada), 1941; B.S., 1942; Ph.D., Brown, 1947.

Michael Wilkinson (1971)
Postdoctoral Research Associate in Center for Surface and Coatings Research
B.S.C., London University, 1963; Ph.D., 1966. Associate Royal Institute of Chemistry, 1968.

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Robert Clifford Williamson (1963, 1964)
Professor of Sociology and Chairman of the Department of Social Relations
B.A., U.C.L.A., 1938; M.A., 1940; Ph.D., Southern California, 1951.
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Willard Ross Yates (1955, 1963)
Professor of Government and Dean of the College of Arts and Science
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.

Thomas Edwin Young (1958, 1966)
Professor of Chemistry
B.S., Lehigh, 1949; M.S., 1950; Ph.D., Illinois, 1952.

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.

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A.B., Hastings (Nebraska), 1927; M.A., Columbia Teachers College, 1935; Ed.D., 1950.

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Jacob Lynford Beaver (1917, 1952)
Professor Emeritus of Electrical Engineering
E.E., Lehigh, 1904; M.S., 1921; Sc.D., Harvard, 1932.

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Chief Nurse and Administrative Assistant Emeritus, Health Service
B.A., Michigan, 1932; R.N., Allentown Hospital, 1939.

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B.S., Lehigh, 1921; M.S., 1925; Ph.D., Cincinnati, 1929.

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A.B., Williams, 1928; Ph.D., Princeton, 1936.

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A.B., Harvard, 1925; A.M., 1926; Ph.D., 1930.

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Dipl. Ing., Berlin, 1922; M.S., Stevens Institute, 1948; Ph.D., Lehigh, 1952.

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Professor Emeritus of Economics
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William Joseph Eney (1936, 1971)
Joseph T. Stuart Emeritus Professor of Civil Engineering
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A.B., Michigan, 1920; A.M., 1923; Ph.D., 1926.

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C.E., Syracuse, 1910; M.S., Lehigh, 1934.

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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.

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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.

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Associate Professor Emeritus of Education
B.S., Northwestern, 1931; M.Ed., Penn State, 1941; D.Sc.Ed., Cedar Crest, 1963.

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.

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, 1971)
Professor 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.

Ralph Newcomb Van Arnam (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

Mahmoud Abd-El-Bary (1970)
Research Associate in Chemical Engineering

John Rodger Adams (1965, 1966)
Assistant Professor of Civil Engineering

Lynn Askew (1970)
Instructor in Education

James L. Bannon (1969)
Assistant Professor of Aerospace Studies

Hanspeter Bieri (1969)
Visiting Assistant Professor of Mathematics

Jean Wright Bishop (1968)
Assistant to Director of University Publications

Linda C. Blanks (1970)
Assistant to Director of Public Information

Joseph Broderway (1969)
Instructor in Military Science

Stephen D. Bryen (1967, 1970)
Assistant Professor of Government

Thomas E. Burke (1969)
Instructor in English

Rudd H. Canaday (1968)
Visiting Lecturer in Electrical Engineering

Richard Carlson
Instructor in Education

Ronald Norman Caron (1965)
Instructor in Metallurgy and Materials Science

John Millar Carroll (1965)
Associate Professor of Industrial Engineering

Michael J. Caruso (1968)
Instructor in Physical Education

Watson Garrard Caudill, Jr. (1968)
Assistant Professor of Military Science

Randall M. Chambers (1966)
Adjunct Associate Professor of Psychology

Shiu C. Chiu (1969)
Research Associate in Physics

Bonny I. Chukwukere (1970)
Visiting Lecturer in Social Relations

Robert Francis Cook (1968)
Instructor in Economics

Robert Joseph Corkhill (1968)
Instructor in Management and Finance

Linda T. Curran (1969)
Production Assistant, University Publications

Kenneth H. Eckelmeyer (1965)
Instructor in Metallurgy and Materials Science

Weston H. Feilbach, Jr. (1968)
Visiting Assistant Professor in Metallurgy and Materials Science

Robert Darrow Fouchaux (1963)
Assistant Professor of Physics

Gilbert Darrel Friend (1966)
Assistant Professor of Mathematics

Earl Benjamin French (1968)
Associate Professor of Management and Finance

Nicholas J. Gainer (1969)
Assistant Director of Placement

David J. H. Garling (1969)
Visiting Associate Professor of Mathematics

J. Harvey Gillespie (1970)
Ford Foundation Intern

James Goodson (1968)
Adjunct Professor of Psychology

Richard T. Gorton (1968)
Instructor in Education

Ronald Charles Gower (1969)
Instructor in Metallurgy and Materials Science

Jon C. Hirsh (1969)
Instructor in English

Arno Holz (1968)
Assistant Professor, Center for the Application of Mathematics

William R. Hoover (1966)
Instructor in Metallurgy and Materials Science

Fred H. Irons (1969)
Instructor in Electrical Engineering

Melvin Robert Jackson (1965, 1967)
Instructor in Metallurgy and Materials Science

Darlene Marilyn Johnson (1965)
Instructor in Education

Vedanth Kadambi (1969)
Visiting Associate Professor of Mechanical Engineering and Mechanics

Michael N. Kaiser (1969)
Visiting Associate Professor of Fine Arts

Nigel J. Kalton (1969)
Visiting Lecturer in Mathematics

Laveen Kanal (1966)
Adjunct Professor in Electrical Engineering

Elsie L. Kennet (1969)
Cataloger, Humanities

Kenneth M. Kensinger (1969)
Visiting Instructor in Social Relations

John Wycliffe Khouri (1967)
Part-time Lecturer in Education

Walter King (1967)
Instructor in Physical Education

Leigh U. Kirby (1970)
Assistant to Director, Development

Sidney Kleinberg (1965, 1968)
Assistant Professor of Chemical Engineering

Stephen Chihchi Ko (1965, 1967)
Instructor in Civil Engineering

Winifred A. Kohls (1969)
Adjunct Associate Professor of History

Carl F. Kowalski (1969)
Instructor in English

Girard E. Krebs (1969)
Assistant Professor of Social Relations

Thomas Charles Kubelius (1948, 1957)
Associate Professor of Business Law

Gunnar Kullerud (1962)
Adjunct Professor of Geochemistry

John Davis Landis (1967)
Instructor in Industrial Engineering

Norman Laws (1969)
Associate Professor, Center for the Application of Mathematics

James Charles Lee (1966)
Assistant in Aerospace Studies

Barbara W. Lex (1969)
Assistant Professor of Social Relations

Elizabeth Mary Liu (1968)
Cataloger, Science

Joseph Logsden (1969)
Associate Professor of History

Herman J. Lumzy (1969)
Ford Foundation Intern

James Michael Lyle (1967)
Assistant Professor of Military Science

Richard Franklin Lynch (1967)
Instructor in Metallurgy and Materials Science

Stuart S. Malawer (1969)
Instructor in Government

Paul J. Marek (1968)
Postdoctoral Associate in Civil Engineering

Charles E. Marple (1968)
Instructor in Education

Thomas P. Martin (1969)
Visiting Assistant Professor of Physics

Clark R. McCauley, Jr. (1969)
Visiting Instructor in Social Psychology

Jane L. McCormick (1970)
Instructor in English

Frances M. McSpedon (1969)
Cataloger, Social Sciences

Urban Meyer (1969)
Instructor in Industrial Engineering

Steven J. Michaels (1970)
Instructor in Mathematics

Theodore Millon (1954, 1959)
Associate Professor of Psychology, Education

Jack Yogishwar Narayan (1968)
Instructor in Mathematics

Pablo H. R. Nashi (1967)
Instructor in Electrical Engineering

William Nelson (1970)
Lecturer in Physics

Joann Spencer Norman (1968)
Instructor in Education

John Donald Oakey (1967)
Instructor in Metallurgy and Materials Science

Sandra Bissel Olsen (1969)
Assistant Reference Librarian

Chester Anthony Page, Jr. (1966, 1968)
Assistant Director of Development

Andrew Parker (1969)
Postdoctoral Research Associate, Center for Marine and Environmental Studies

John T. Petrakis (1966)
Instructor in Finance

Henry Phillips (1969)
Instructor in Military Science

Hugh L. Polk (1970)
Instructor in Education, Centennial School

Timothy H. Polk (1970)
Instructor in Education, Centennial School

Linda K. Rambler (1966, 1969)
Reference Librarian, Mart Science and Engineering Library

Edward Franklin Reis
Part-time Lecturer in Electrical Engineering

Joseph H. Reno (1947, 1961)
Part-time Physician, Health Service

George Roemhild (1970)
Lecturer in Physics

Joel C. W. Rogers (1966, 1968)
Assistant Professor of Mathematics

Elaine Rohde (1969)
Systems Programmer

John Edward Roth
Part-time Lecturer in Electrical Engineering

Eliezer Rubin (1969)
Visiting Associate Professor of Chemical Engineering

Robert Benjamin Runk (1966)
Assistant Professor of Metallurgy and Materials Science

Edward Samulewicz (1970)
Instructor in Counselor Education

James Walter Scible III (1967)
Instructor in Physical Education, Varsity Lacrosse Coach and Freshman Football Coach

Brian R. Seymour (1968, 1969)
Assistant Professor, Center for the Application of Mathematics

Albert Siegel (1969)
Manager, Systems and Procedures, Computing Center

James William Simpson (1967)
Instructor in Metallurgy and Materials Science

Marion A. Spicer (1968)
Instructor in Military Science

Thomas R. Steel (1968)
Assistant Professor, Center for the Application of Mathematics

Robert L. Stone (1967)
Instructor in Accounting

Stephen S. Strunk (1964)
Instructor in Metallurgy and Materials Science

Ruth Y. Super (1960)
Assistant to the Dean, Graduate School
Retired August 1, 1970.

Frank A. Szumilo (1969)
Instructor in Economics

Charles F. Tayler III (1968)
Instructor in Physical Education

Michael S. Teitelbaum (1970)
Visiting Instructor in Social Relations

Armin Thellung (1969)
Visiting Professor of Physics

H. Louis Thompson (1969)
Adjunct Professor in Management and Finance

Dennis Francis Torok, Jr.
Instructor in Mechanical Engineering

Efraim Turban (1966, 1968)
Associate Professor of Management Science

R. Jay Turner (1970)
Visiting Associate Professor in Social Relations

John C. Turoczi (1970)
Instructor in Education

Joseph Jerome Veilleux (1966)
Assistant in Aerospace Studies

Harry R. Walker (1968)
Assistant in Aerospace Studies

Marie Weil (1968)
Coordinator of Community Relations and Volunteer Services, and Instructor in Social Relations

John Paul Wettrau (1968)
Systems Analyst

William A. Wojciechowski (1966)
Lecturer in Aerospace Studies

Francis Joseph Wuest (1962, 1965)
Professor and Chairman of the Department of Psychology

Sondra Yates (1970)
Assistant to Director, Public Information

Jean Zingler (1969)
Instructor in Centennial School

Deceased

Frank Swan Beale (1930, 1964)
Associate Professor Emeritus of Mathematics
December 30, 1970.

Frederick Alden Bradford (1926, 1957)
Professor Emeritus of Finance
January 23, 1971.

Elmer Clark Bratt (1929, 1968)
Director Emeritus, Center for Business Economics
November 9, 1970.

John S. Cartwright (1962)
Professor of Education
May, 1970.

Raymond Eugene Fuessle (1953)
Chaplain Emeritus and Associate Professor of Religion
January 14, 1971.

Lawrence Henry Gipson (1924, 1952)
Research Professor Emeritus of History
September 16, 1971.

Percy Lee Sadler (1946, 1962)
Professor Emeritus in Physical Education
November, 1970.

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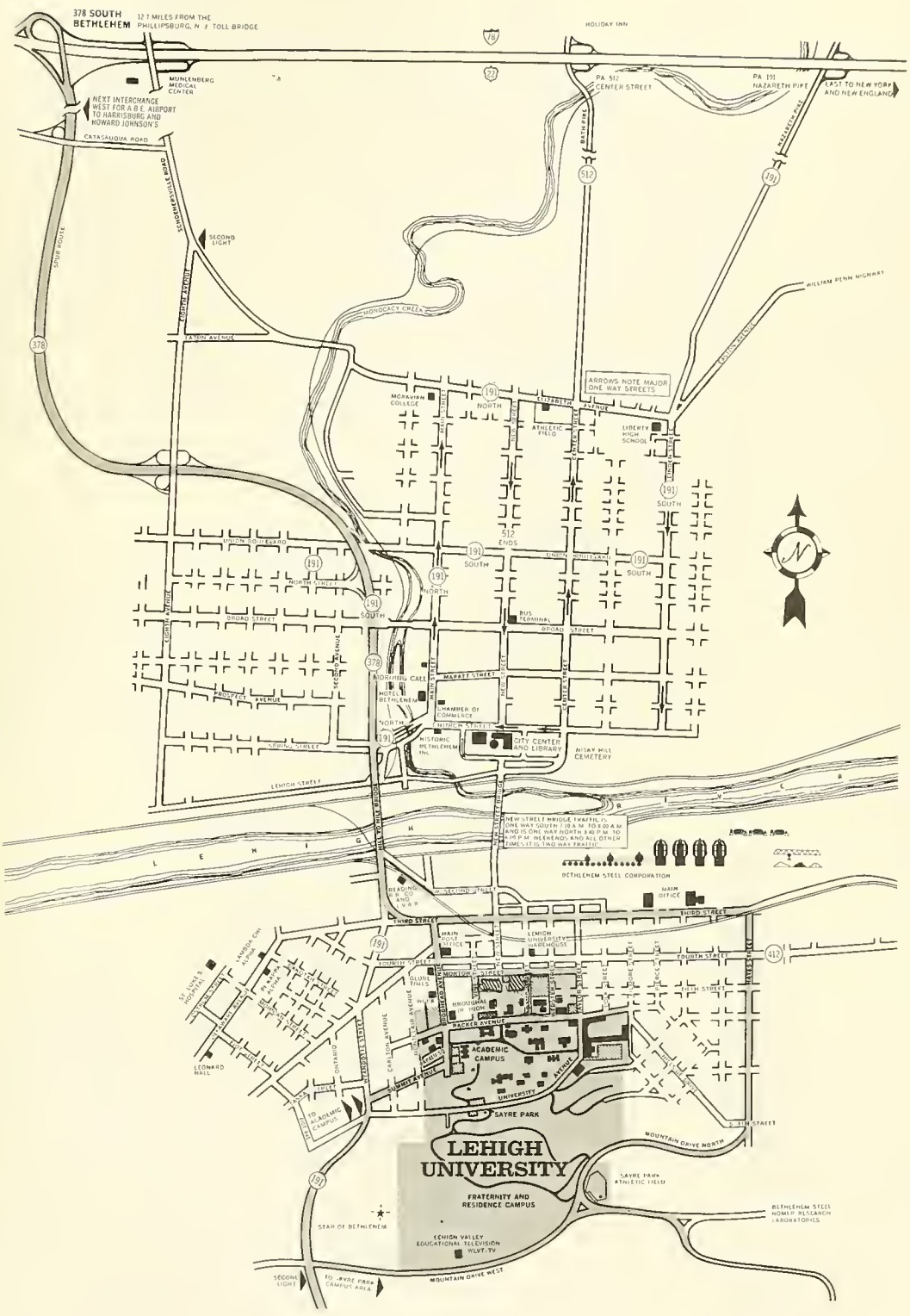
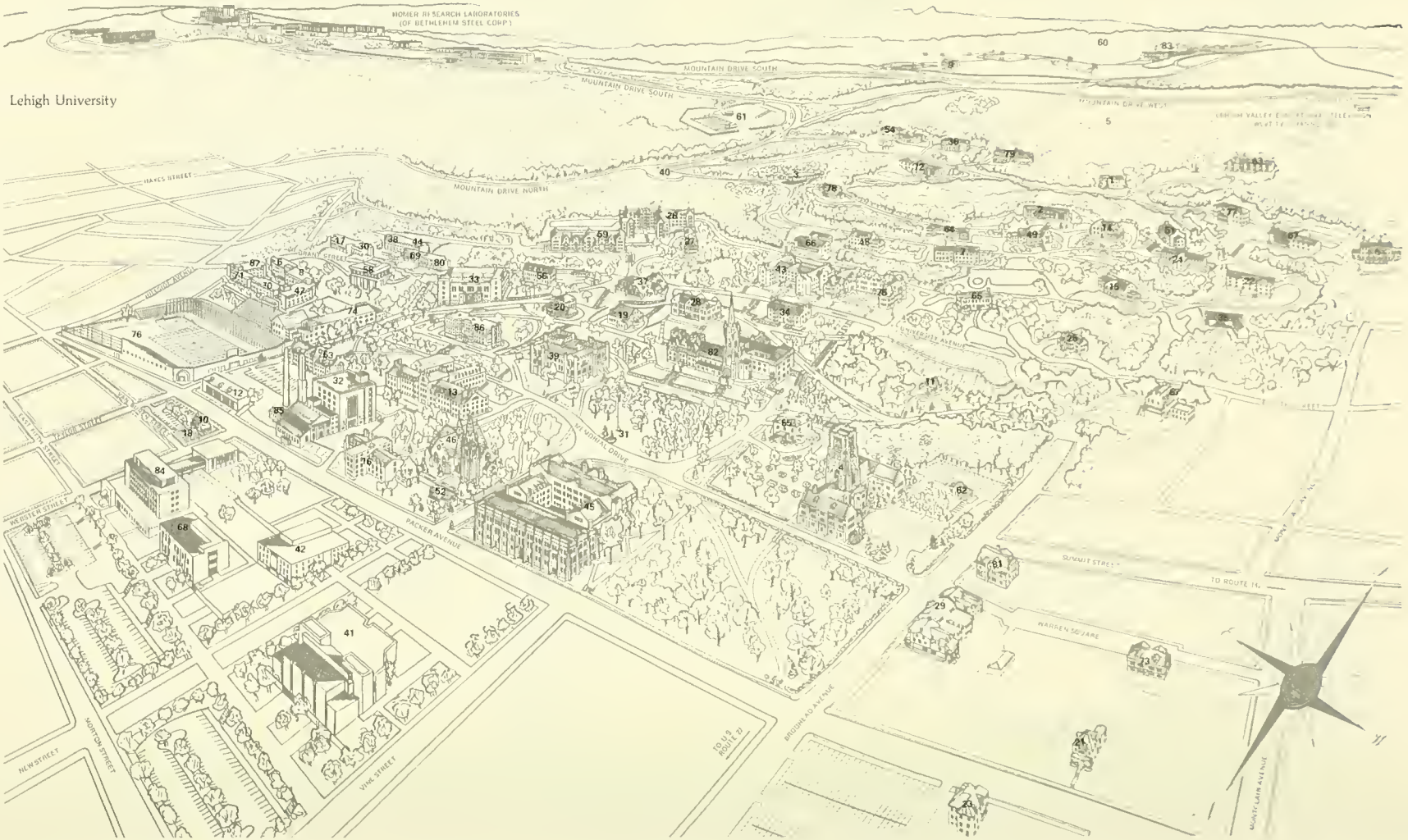

378 SOUTH
BETHLEHEM
12.7 MILES FROM THE PHILLIPSBURG, N. J. TOLL BRIDGE
HOLIDAY INN
MUNLENBERG MEDICAL CENTER
NEXT INTERCHANGE WEST FOR A.B.E. AIRPORT TO HARRISBURG AND HOWARD JOHNSON'S
CATASAUQUA ROAD
SCHOENERSVILLE ROAD
STOP ROUTE
SECOND LIGHT
CORNING AVENUE
EATON AVENUE
MONOCACY CREEK
PA 512 CENTER STREET
PA 191 NAZARETH PIKE
EAST TO NEW YORK AND NEW ENGLAND
WILLIAM PENN HIGHWAY
ARROWS NOTE MAJOR ONE WAY STREETS
MORAVIAN COLLEGE
ATHLETIC FIELD
LIBERTY HIGH SCHOOL
ELIZABETH AVENUE
NORTH
SOUTH
512 ENDS
UNION BOULEVARD
NORTH STREET
BROAD STREET
BUS TERMINAL
MARKET STREET
CHURCH STREET
MORAVIAN CAFE
HOTEL BETHLEHEM
CHAMBER OF COMMERCE
CITY CENTER AND LIBRARY
MISKY MILL CEMETERY
HISTORIC BETHLEHEM INC.
SPRING STREET
LEHIGH STREET
NEW STREET BRIDGE TRAFFIC IS ONE WAY SOUTH 7:00 A.M. TO 9:00 A.M. AND IS ONE WAY NORTH 3:40 P.M. TO 6:40 P.M. WEEKENDS AND ALL OTHER TIMES IT IS TWO WAY TRAFFIC
BETHLEHEM STEEL CORPORATION
MAIN OFFICE
THIRD STREET
MAIN POST OFFICE
LEHIGH UNIVERSITY WAREHOUSE
FOURTH STREET
FIFTH STREET
GLOBAL FINES
PACKER AVENUE
ACADEMIC CAMPUS
UNIVERSITY AVENUE
SAYRE PARK
LEONARD HALL
TO ATLANTIC CITY
LEHIGH UNIVERSITY
FRATERNITY AND RESIDENCE CAMPUS
MOUNTAIN DRIVE NORTH
SAYRE PARK ATHLETIC FIELD
BETHLEHEM STEEL HOMER RESEARCH LABORATORIES
STAR OF BETHLEHEM
LEHIGH VALLEY EDUCATIONAL TELEVISION WLVT-TV
SECOND LIGHT
TO SAYRE PARK CAMPUS AREA
MOUNTAIN DRIVE WEST

Lehigh University



1. Alpha Chi Rho
2. Alpha Sigma Phi
3. Alpha Tau Omega
4. Alumni Memorial Building (administration)
5. Arboretum
6. Beardslee House
7. Beta Theta Pi
8. Carothers House
9. Centennial School
10. Center for Application of Mathematics
11. Center for Business Economics & Urban Studies
12. Central Heating and Refrigeration Building
13. Chemistry Building
14. Chi Phi
15. Chi Psi
16. Christmas-Saucon Hall
17. Congdon House
18. Color Laboratory and Counseling and Testing
19. Coppee Hall
20. Coxe Laboratory
21. Delta Chi Annex
22. Delta Phi
23. Delta Sigma Phi
24. Delta Tau Delta
25. Delta Upsilon
26. Dravo House
27. Drinker House
28. Drown Hall
29. Education Buildings
30. Emery House
31. Flagpole
32. Fritz Laboratory
33. Grace Hall
34. Student Services Building (Health Cntr.)
35. Kappa Alpha
36. Kappa Sigma
37. Lamberton Hall
38. Leavitt House
39. Linderman Library
40. Lookout
41. Maginnes Hall
42. Mart Library
43. McClintic-Marshall House
44. McConn House
45. Packard Laboratory
46. Packer Memorial Church
47. Palmer House
48. Phi Delta Theta
49. Phi Gamma Delta
50. Phi Kappa Theta
51. Phi Sigma Kappa
52. Philosophy Building
53. Physics Building
54. Pi Lambda Phi
55. President's House
56. Price Hall
57. Psi Upsilon
58. Rathbone Dining Hall
59. Richards House
60. Saucon Valley Playing Fields
61. Sayre Park Intramural Field
62. Sayre Psychology Laboratory
63. Sigma Alpha Mu
64. Sigma Chi
65. Sigma Nu
66. Sigma Phi
67. Sigma Phi Epsilon
68. Sinclair Laboratory
69. Smiley House
70. Stevens House
71. Stoughton House
72. Tau Delta Phi
73. Tau Epsilon Phi
74. Taylor Gymnasium and Field House
75. Taylor House
76. Taylor Stadium
77. Theta Chi
78. Theta Delta Chi
79. Theta Xi
80. Thornburg House
81. Town House
82. University Center
83. Varsity House
84. Whitaker Laboratory
85. Wilbur Power House and Laboratory
86. Williams Hall
87. Williams House

Research Centers and Institutes and Academic Deans' Offices

29. Bureau of Educational Service (Education Building)
10. Center for Application of Mathematics (203 E. Packer Ave., and also Figlear Building–the latter not on this map)
11. Center for Business Economics and Urban Studies
42. Center for Information Science (Mart Library)
86. Center for Marine and Environmental Studies (Williams Hall)
68. Center for Surface and Coatings Research (Sinclair Lab)
45. Computing Center (Packard Lab)
45. Institute of Fracture and Solid Mechanics (Packard Lab)
84. Institute for Metal Forming (Whitaker Lab)
13. Institute for Pathobiology (Chemistry Building)
13. Marine Geotechnical Lab (Chemistry Building)
20. Materials Research Center (Coxe Lab)
68. National Printing Ink Research Institute (Sinclair Lab)
39. Office of Research (Linderman Library)
41. College of Arts and Science (Maginnes Hall)
28. College of Business and Economics (Drown Hall)
45. College of Engineering (Packard Lab)
84. Graduate School (Whitaker Lab)

Buildings Not on This Map

Delta Chi–233 W. Packer Avenue
Figlear Building (Center for the Application of Mathematics)–Fourth and New Streets
Lambda Chi Alpha–515 Delaware Avenue
Newman Center–449 Carlton Avenue
Pi Kappa Alpha–514 Delaware Avenue
Service Building and Warehouse–Fourth and Adams Streets

Lehigh

University Catalog

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